STUDIES ON PLANT-PARASITIC NEMATODES OF UTTAR PRADESH (North India)[1]

By

MOHAMMAD RAFIQ SIDDIQI[2]

AUGUST, 1960

---

1 **Thesis presented for the degree of Doctor of Philosophy in the Aligarh Muslim University, Aligarh (U.P.), India.**

2 **Research Scholar in the Department of Zoology, Aligarh Muslim University.**

ABSTRACT

STUDIES ON PLANT-PARASITIC NEMATODES OF UTTAR PRADESH, (NORTH INDIA)*

By

MOHAMMAD RAFIQ SIDDIQI

Plant-parasitic nematodes play a vital role in the agricultural economy of a country. A large number of nematodes are known to be destructive to ornamental plants, cultivated crops, vegetables and fruit trees etc. Unfortunately the study of these pests is still in its infancy in India. These require an intensive study before something can be done to improve the agricultural economy of this country which is one of the oldest known agricultural countries of the world. The present work is undertaken with this end in view.

This work is the outcome of an intensive study made on the morphology and systematics of the plant-parasitic nematodes collected in various localities of U. P. It also includes the results of the experimental studies on the root-lesion nematodes, Pratylenchus musicola (Cobb), attacking citrus trees in U. P. Accordingly the work has been divided into two parts. Part I deals with the morphology and taxonomy

---

* Thesis submitted for the degree of Doctor of Philosophy of the Aligarh Muslim University, Aligarh (U.P.), India.

C O N T E N T S

---

1) & 2) have been published with the permission of the University. Ref. 1). Nematologica 4 (1959): 217-222; 2). Nematologica 5 (1960).

---

3) has been published with the permission of the University. Ref. Proc. Helm. Soc. Wash. 26 (1959): 151-163.

---

4) has been published with the permission of the University. Ref. Proc. Helm. Soc. Wash. 27 (1960): 22-27.

STUDIES ON PLANT-PARASITIC NEMATODES OF UTTAR PRADESH, NORTH INDIA

INTRODUCTION

In recent decades the plant-parasitic nematodes have received a great deal of attention from scientists with the result that a new science called Phytonematology has emerged dealing with the various biological aspects of the nematodes living in a parasitic type of association with the plant tissues. A large number of nematode genera of the two orders, Tylenchida and Enoplida, have been shown by recent workers to be destructive to ornamentals, cultivated crops, vegetables and fruit trees etc. With the discovery of these pests and the knowledge of their behaviour it has been possible to get better crops by using improved agricultural devices in many parts of the world. Unfortunately, the study of the plant-parasitic nematodes is still in its infancy in India.

Some of the important plant parasitic nematodes are known from India. In 1913, Butler described Ditylenchus angustus found associated with the dangerous ufra disease of rice in Bengal. Cobb (1913) described a new scale nematode, Iota squamosum (now Criconema squamosum (Cobb, 1913) Taylor, 1936), collected off the roots of mango tree in Bangalore, South India. The oldest known wheat-gall nematode, Anguina tritici (Steinbuch, 1799) Filipjev, 1936, has also been reported by various authors from India. An-

other species, A. cecidoplastes (Goodey, 1934) Filipjev, 1936, is known to cause gall-formation on grass, Andropogon pertusus, in Bangalore, Chikmagalur, Coimbatore and Palghat in South India. Goodey (1953) described two new nematode species, Ditylenchus drepanocercus and Aphelenchoides sphaerocephalum, associated with leaf-blotch disease of Evodia roxburghiana Benth., an evergreen tree in Western Ghats (S. India). Injury to coffee seedlings due to Pratylenchus sp. in South India has been reported by Thomas (1948). Very recently, Das (1960) has added much to our knowledge of plant nematodes of India. He has described a number of species from Hyderabad, South India. Besides some already described species, Das (1960) gave the descriptions of a new genus, Leiperotylenchus and 19 new species. His method of collection, however, was such that a large number of ecto-parasitic nematode genera must have been overlooked.

The importance of nematodes in agriculture is now largely being recognized in India. There are a large number of problems on various aspects of Phytonematology facing this country. These require an intensive study before something can be done to improve the agricultural economy of this country which is one of the oldest known agricultural countries of the world. The present work is devoted to this ultimate cause.

The present work is the outcome of the examination of nematode associated with plants, shrubs and trees, collected in a general survey of various districts of Uttar Pradesh, a North Indian State, during a period of four years from 1955 to 1959. It also includes the results of the preliminary studies made on the

nematodes attacking citrus trees in this region. The work has been divided into two parts. Part I deals with the morphology and systematics of the species of plant-parasitic or suspected plant-parasitic nematodes. In all, 59 species out of which 31 are new to science have been described and illustrated with suitable diagrams. These belong to 29 genera representing 17 sub-families from 10 different families of nematodes. Three new genera and one new sub-family have been erected to receive species with peculiar morphological characters. A list of new host records described in the text has been given at the end. Part II deals with the behaviour and distribution of important citrus nematodes in various districts of Uttar Pradesh. Preliminary observations in relation to relative abundance, host range, egg-laying and hatching, pathogenicity and control of the lesion nematodes, Pratylenchus musicola (Cobb, 1919) Filipjev, 1936, have also been made.

It is difficult to ascertain, in many instances, whether a particular nematode species collected in, or in the vicinity of, the plant tissues is parasitic in habit. There are many species which are not obligate parasites. Nevertheless, the general appearance of the body, the buccal armature, the intestinal contents and the nature of the association with the plant tissues sometimes give the clue of the nematode habit. The nematodes described here, therefore, are either plant-parasitic or suspected plant-parasitic species.

ACKNOWLEDGMENTS

The author wishes to place on record his grateful thanks to Dr. M. A. Basir under whose guidance the entire work was done; to Prof. M. B. Mirza, Head of the Department of Zoology, for providing various facilities; and to the Ministry of Education, Government of India, for the award of a Research Training Scholarship which made these investigations possible. He is also indebted to Dr. J. Basil Goodey and Dr. Mary T. Franklin of Rothamsted Experimental Station, Harpenden, England, for their valuable suggestions and kind help which the author had been getting from time to time. Thanks are also due to Drs. A. C. Tarjan, S. D. van Gundy, A. Morgan Golden, J. W. Seinhorst, Michel Luc, Luiz Gonzaga E. Lordello and Richard W. Timm for kindly sending the specimens from their countries which were of great help to the author in his comparative studies.

PART I

A GENERAL SURVEY OF PLANT-PARASITIC NEMATODES OF UTTAR PRADESH

Material and methods: A general survey for determining the plant-parasitic nematodes of Uttar Pradesh was conducted by the author from August, 1955 to August, 1959. A large variety of plants including grasses, weeds, ornamentals, vegetables and crop plants as well as fruit trees were examined for this purpose. The major part of the survey-work was done in Aligarh District (Western U. P.). In the northern region of U. P. the survey was conducted in Pilibhit, Nainital and Almora districts while the southern region of this state was included by surveying Banda and Jhansi districts. Thus it was possible to cover a large territory which included both plains as well as hilly and forest regions.

Samples of roots and soil around them were collected in plastic bags which in turn were stored in tin boxes. These samples were later processed for nematode determination. Above-ground parts e. g. stems, barks, leaves etc. were also examined in cases where presence of nematodes was suspected.

The soil samples were processed by roiling them in a bucket full of water and then screening the aliquot twice or thrice through sieves with meshes of 120 and 66 microns. The catches on both the screens were then washed off into a glass trough and examined for the presence of the nematodes under a dissecting binocular microscope. The root samples were chopped up into small pieces and placed submerged in water in glass troughs which were

then covered and left over-night. On the following day, the worms that evacuated from the roots were collected, killed and fixed for examination.

For the taxonomic studies, the nematodes were killed by gradual heat and fixed at least over-night in Franklin's F. A. Fixative (10 parts formol, 10 parts acetic acid and 80 parts water). The worms were later transferred gradually to dehydrated glycerine and mounted in the same medium. Glass wool was always placed between the slide and the coverglass to check the pressure on the specimens. Live mounts as well as temporary water- and lactophenol-mounts were also studied.

The measurements of the worms are represented in the formula used by de Man (1884). The letters 'a', 'b', and 'c' have been preferred in place of 'α', 'β', and 'γ' respectively. An explanation of these indices is given below.

a = The total body length of the worm divided by its maximum body width.

b = The total body length of the worm divided by the length of its oesophagus.

c = The total body length of the worm divided by the length of its tail.

V = The position of the vulva from the anterior end of the body expressed in percentage of the total body length. The superior figure indicates the extent of the ovary from the vulva.

T = The extent of the male gonad from cloaca expressed in percentage of the total body length.

Super-family Tylenchoidea Chitwood and Chitwood, 1937

Diagnosis: Tylenchida: Orifice of dorsal oesophageal gland in pre-corpus usually near spear base; bursa usually present, not supported by ribs.

Type family: Tylenchidae ~~Filipjev, 1934, in part.~~ Orley, 1880

Key to families of Tylenchoidea

1. Median oesophageal bulb with its valvular apparatus absent ..... Neotylenchidae Thorne, 1949
   Median oesophageal bulb with its valvular apparatus present 2
2. Females saccate; bursa in male absent 3
   Females not saccate, except in Nacobbus, Rotylenchulus and Cacopaurus; bursa in male present except in Eutylenchus, Miculenchus, and occasionally in some members of Criconematidae 4
3. Male tail short, rounded; female gonads paired ... . Heteroderidae Thorne, 1949
   Male tail elongate; female gonad single .... Tylenchulidae ~~Raski, 1957~~ Kirjanova, 1955
4. Cuticle generally heavily annulated or squamose; median oesophageal bulb greatly enlarged; isthmus reduced ..... Criconematidae Thorne, ~~1949~~ 1943

Cuticle not heavily annulated or squamose; median oesophageal bulb small to moderately developed; isthmus narrow, elongate 5

5. Internal head sclerotization abnormally strong, yellowed ..... Hoplolaimidae (Filipjev, 1941) Wieser, 1953

Internal head sclerotization normal .....
..... Tylenchidae ~~Filipjev, 1934~~ Orley, 1880

Family Tylenchidae ~~Filipjev, 1934~~ Orley, 1880

Diagnosis: Tylenchoidea: Female typically vermiform. Median oesophageal bulb small to moderately developed. Isthmus narrow, elongate. Cephalic frame-work not heavily sclerotized. Tails of both sexes more than one-and-a-half anal body diameters long. Bursa in male present except in Eutylenchus and Miculenchus.

Type sub-family: Tylenchinae ~~Filipjev, 1934~~. [de Man, 1876] Maximow, 1929

Key to sub-families of Tylenchidae

1. Isthmus forming basal oesophageal bulb enclosing oesophageal glands ..... Tylenchinae ~~Filipjev, 1934~~

Isthmus not forming basal oesophageal bulb, oesophageal glands free 2

2. Spear slender, much elongated in relation to its breadth; striae following contour of tail terminus

..... Belonolaiminae Whitehead, 1959

Spear normal; striae not following contour of tail terminus ..... Telotylenchinae n. sub-fam.

Sub-family Tylenchinae Filipjev, 1934

Diagnosis: Tylenchidae: Basal portion of oesophagus forming a distinct bulb. Oesophageal glands enclosed in basal oesophageal bulb.

Type genus: Tylenchus Bastian, 1865.

Key to genera of Tylenchinae

1. Head armed with setae 2
   Head not armed with setae 3
2. Cuticle with transverse and longitudinal striae .....
   ..... Atylenchus Cobb, 1913
   Cuticle with transverse striae only .....
   ..... Eutylenchus Cobb, 1913
3. Bursa absent ..... Miculenchus Andrássy, 1959
   Bursa present 4
4. Body greatly attenuated, a = 150 .....
   ..... Ecphyadophora de Man, 1921
   Body not greatly attenuated, a = 50 or less 5

5. Tail rounded, cuticle much swollen 6

Tail cuticle not swollen 7

6. Ovaries paired; spear much elongated .....

..... macrotrophurus Loof, 1958

Ovary single; spear not much elongated .....

..... Trophurus Loof, 1956

7. Base of spear furcate.....Chitinotylenchus Micoletzky, 1922

Base of spear not furcate 8

8. Spear much elongated .....Dolichodorus Cobb, 1914

Spear not much elongated 9

9. Female body obese; gonad cells arranged about a rachis 10

Female body cylindrical, not obese; gonad cells not arranged about a rachis 11

10. Longitudinal wings of cuticle present .....

..... Paranguina Kirjanova, 1955

Longitudinal wings of cuticle absent .....

..... Anguina Scopoli, 1777

11. Female tail attenuated or filiform 12

Female tail not attenuated or filiform 14

12. Distance from anterior end of body to median oesophageal bulb lesser than that from latter to base of oesophagus; amphid apertures usually small, pore-like ..... Tylenchus Bastian, 1865

Distance from anterior end of body to median oesophageal bulb equal to or greater than that from latter to base

of oesophagus; amphid apertures large, slit-like 13

13. Orifice of dorsal oesophageal gland close to spear base ..... Psilenchus de Man, 1921

Orifice of dorsal oesophageal gland 9-12 μ behind spear base ..... Basiria n. g.

14. Ovaries paired 15

Ovary single 16

15. Female tail pointed or sub-acute.....

..... Tetylenchus Filipjev, 1936

Female tail blunt, rounded... Tylenchorhynchus Cobb, 1913

16. Lateral lips enlarged ... Sychnotylenchus Rühm, 1956

Lateral lips not enlarged 17

17. Orifice of dorsal oesophageal gland close to spear base ..... Ditylenchus Filipjev, 1934

Orifice of dorsal oesophageal gland about one spear length behind spear base ... Leiperotylenchus Das, 1960

Genus Tylenchus Bastian, 1865

Diagnosis: Tylenchinae: Lip region elevated, set off or continuous with body contour, may or may not be striated. Amphid apertures pore-like, rarely slit-like. Phasmids usually not observed. Cephalic frame-work not sclerotized. Spear weak or strong, knobed at base. Distance from anterior end of body to median oesophageal bulb not more than that from latter to base of oesophagus. Basal oesophageal bulb pyriform, set off from intestine, enclosing oesophageal glands. Vulva located in posterior half of body. Gonad single, prodelphic. Post-uterine sac usually present, short. Bursa adanal, sometimes rudimentary. Spicula tylenchoid; gubernaculum simple, trough-shaped, sometimes rudimentary. Tail of both sexes elongate, filiform.

Type species: Tylenchus davainii Bastian, 1865.

Key to sub-genera of Tylenchus

1. Cuticle coarsely striated; spear well developed, with distinct basal knobs; median oesophageal bulb rounded... 2

   Cuticle finely striated; spear weakly developed; median oesophageal bulb oval 3

2. Head slightly set off; tail comparatively short, ventrally curved ..... Tylenchus Andrássy, 1954

   Head well set off; striae coarse; tail elongate, filiform ..... Aglenchus Andrássy, 1954

3. Large-sized; striae distinct; bursa well developed ... . Filenchus Andrássy, 1954
   Small-sized; striae very fine; bursa rudimentary .... Lelenchus Andrássy, 1954

Sub-genus Aglenchus Andrássy, 1954

Diagnosis: Tylenchus: Body relatively small, o.3-0.9 mm. Cuticle distinctly striated. Lip region set off. Spear well developed, with distinct basal knobs. Median oesophageal bulb strongly developed, rounded. Vagina often thick-walled. Tail elongate, filiform.

Type species: Tylenchus (Aglenchus) agricola de Man, 1884

Key to species of Aglenchus

1. Body with transverse and longitudinal striae 2
   Body with transverse striae only 3
2. Longitudinal striae 18-24 in number; post-uterine branch rudimentary ..... costatus de Man, 1921
   Longitudinal striae 10 in number; post-uterine branch twice the anal body diameter ... sachsi Hirschmann, 1952
3. Body more than 0.6 mm. long; body striae not coarse .. .. thornei Andrássy, 1954
   Body less than 0.6 mm. long; striae coarse 4
4. Spear about 10 µ long, with rounded basal knobs; post-uterine branch absent 5
   Spear less than 10 µ long; with elongated basal knobs; post-uterine branch present 6

5. Lip region striated ..... agricola de Man, 1884
   Lip region unstriated ..... paragricola Paetzold, 1958
6. Body less than 0.4 mm. long ..... bryophilus Steiner, 1914
   Body more than 0.4 mm. long ..... parvus n. sp.

Tylenchus (Aglenchus) parvus n. sp.

(Plate 1, Fig. A-C)

Measurements: 8 females: Length = 0.43-0.54 mm.; a = 28-31; b = 5.8-7.2; c = 3.8-4.2; V = 61-66%; spear = 7-8 µ.

Female (Holotype): Length = 0.53 mm.; a = 30; b = 6.4; c = 4.2; V = $^{51-}64.7^{-1.9}$%.

Body cuticle marked with distinct, coarse striae, 2.1 µ apart on middle of body. Lateral fields in form of plain bands. Deirids and phasmids not observed. Lip region elevated, continuous with body contour; its striae not distinct. Buccal spear weak, 7.8 µ long; basal knobs minute, elongated, 1.4 µ across. Outlet of dorsal oesophageal gland close to spear base. Precorpus a cylindrical tube, shorter in length than isthmus. Median oesophageal bulb ovate, with a weakly developed, valvular apparatus. Isthmus long, crossed by nerve ring anterior to its middle. Excretory duct opening at level of distal end of basal oesophageal bulb which is sac-like and set off from intestine. Hemizonid appearing as a slightly marked transparent area, located just anterior to excretory pore, extending about two body annules.

Vulva a depressed, transverse slit. Vagina thick-walled, at right angles to body axis. Post-uterine sac about one vulvar

PLATE 1

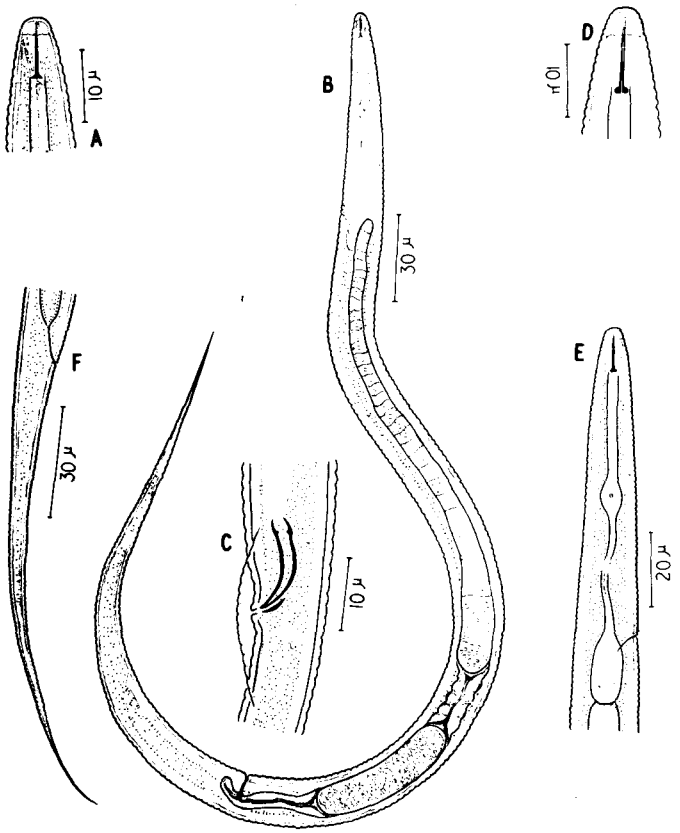


Plate 1. Figures A-C, Tylenchus (Aglenchus) parvus. A. Head end of female; B. Female; C. Bursa, spicula and gubernaculum in male. D-F, Tylenchus (Filenchus) filiformis. D. Head end of female; E. Oesophageal region of female; F. Tail of female.

body diameter long. Uterus highly muscular, with single egg. The latter more than four times as long as broad, 51 µ long by 12 µ wide. Sperms stored in distal end of uterus. Ovary prodelphic, outstretched, extending up to basal oesophageal bulb; its oöcytes arranged in single file except for a few in region of multiplication. Rectum short, obscure, opening outside through an indistinct anus. Vulva-anus distance 63 µ long, half the length of tail. Tail elongated, filiform, regularly tapering to finely rounded terminus.

Male (Allotype): Length = 0.45 mm.; a = 30; b = 6; c = 4; T = 39%.

Cuticle coarsely annulated; striae 1.8 µ apart on mid-body. Lateral fields not marked by incisures. Spear 7.5 µ in length. Testis single, outstretched; spermatocytes first arranged in single file then in double rows. Bursa weak, crenate, originating at level of head of spicula and terminating about one body width behind cloaca. Spicules paired, ventrally arcuate, distinctly cephalated, 14 µ long. Gubernaculum simple, disc-like, 4 µ long. Tail similar to that of female.

Holotype: Female collected on 8th December, 1958; slide no. PN/T/1-001, deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/1-002; other data same as for holotype.

Type habitat: Collected around roots of grass, Cynodon dactylon Pers.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Tylenchus (Aglenchus) with the above measurements and general description, distinctive because of relatively small size of body, coarsely striated cuticle, spear measuring 7-8 μ in length, vulva located at 61-66 per cent of body from anterior end, a short post-uterine sac, vulva-anus distance about half the tail length, tail being more than 110 μ long, and size of egg and spicula.

T. (A.) parvus resembles closely with T. (A.) bryophilus Steiner, 1914, from which it can be differentiated by a longer and more slender body, more elongate egg, longer tail, and more ventrally curved and larger spicules in male. This species has also some similarities with T. striatus Das, 1960, but is distinct in having a more anteriorly located vulva, a shorter uterine branch, and a longer tail.

Sub-genus Filenchus Andrássy, 1954

Diagnosis: Tylenchus: Medium-sized or large forms. Head continuous with body contour. Cuticle moderately to finely striated; striae always distinct. Spear rather weakly developed. Median oesophageal bulb ovate. Bursa moderately developed. Tail elongate, filiform.

Type species: Tylenchus (Filenchus) filiformis Bütschli, 1873

Tylenchus (Filenchus) filiformis Bütschli, 1873

(Plate 1, Fig. D-F)

Measurements: 3 females: Length = 0.61-0.64 mm.; a = 28-32; b = 6-7; c = 5-5.3; V = 61-63.5%. spear = 10-11.5 μ.

Female: Body slightly ventrally arcuate. Striae 1.2 μ apart. Lateral fields with 4 incisures. Spear 11 μ in length. Basal knobs of spear 1.8 μ across. Hemizonid about 2 body annules long, just anterior to excretory pore, near distal end of basal oesophageal bulb. Cardia small, conoid. Post-uterine branch only slightly less than one vulvar body diameter. Sperms stored in an elongated spermatheca at the distal end of the uterus. Ovary single, prodelphic; oöcytes arranged in single file. Tail long, filiform, ending in a pointed terminus. Striae on tail distinct throughout its length.

Male: Not found.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Habitat and distribution: An almost cosmopolitan species. Occasional specimens of this species have been collected by the author around roots of Citrus limon (L.) Burm. and Mangifera indica L. (mango) in Aligarh (U. P.), India.

Diagnosis and relationship: Tylenchus (Filenchus) with the above measurements and general description. It is distinguished by size of the body; distinct transverse striae averaging 1.2 μ apart, spear measuring 10-11.5 μ long, posterior uterine sac slightly less than one vulvar body width long, and distinct rectum and anus, and an elongate, filiform tail ending in a pointed terminus.

It resembles T. (F.) polyhypnus Steiner and Albin, 1946 and T. (Aglenchus) agricola de Man, 1884. From the former it can be differentiated by the less coarsely and more distinctly striated cuticle, larger buccal spear, longer tail; from the latter it

can be distinguished by more posteriorly located vulva and presence of a post-uterine sac.

Genus Tylenchorhynchus Cobb, 1913

Syn. Bitylenchus Filipjev, 1934

Diagnosis: Tylenchinae: Lip region continuous with or set off from body contour. Cephalic frame-work with or without sclerotization. Lateral fields distinct, with 3-6 incisures. Phasmids prominent, pore-like, located well behind the anus. Spear fairly strong, with three basal knobs. Cardia present. Vulva near middle of body. Gonads didelphic, outstretched in opposite directions. Spermatheca usually present. Female tail bluntly rounded, usually two or more times as long as anal body diameter. Bursa enveloping entire tail. Spicula and gubernaculum Tylenchoid.

Type species: Tylenchorhynchus cylindricus Cobb, 1913

Key to species of Tylenchorhynchus

1. Female tail mucronate ..... paucus Kirjanova, 1951
   Female tail not mucronate 2
2. Cuticle marked by longitudinal striae 3
   Cuticle not marked by longitudinal striae 11
3. Lateral fields with 4 incisures 4
   Lateral fields with 6 incisures 6

4. Lip region marked by 2-3 striae... *claytoni* Steiner, 1937
   Lip region marked by 5-6 striae 5
5. Lip region set off by constriction .....
   ..... *microphasmis* Loof, 1959
   Lip region not set off by constriction .....
   ..... *lamelliferus* (de Man, 1880)
6. Annules extending around tail terminus 7
   Annules not extending around tail terminus 8
7. Lip region continuous with body contour... *rugosus* n. sp.
   Lip region set off from body contour.. *tessellatus* Goodey, 1952
8. About 60 longitudinal striae on mid-body .....
   ..... *quadrifer* Andrássy, 1952
   About 24-32 longitudinal striae on mid-body 9
9. Lip region continuous ..... *ornatus* Allen, 1955
   Lip region set off 10
10. Body length 0.63-0.78 mm.; c = 12-15 .. *lenorus* Brown, 1956
    Body length 0.76-1.04 mm.; a = 17.1-18.5 .....
    ..... *tartuensis* Krall, 1959
11. Lateral fields with 3 incisures .. *bivittatus* n. sp.
    Lateral fields with 4 incisures 12
    Lateral fields with 5 incisures 37
    Lateral fields with 6 incisures 38
12. Female tail hook-shaped, with a 'bursa' .....
    ..... *bursifer* Loof, 1959
    Female tail normal 13
13. Annules extending around tail terminus 14
    Annules not extending around tail terminus 21

14. Lip region set off by constriction 15

Lip region continuous 16

15. Spear 14-15.5 μ long, gubernaculum with expanded distal end ..... indicus n. sp.

Spear 18-19 μ long, gubernaculum simple .....

.....dubius (Bütschli, 1873)

16. Tail conoid ..... eremicolus Allen, 1955

Tail cylindroid 17

17. Lip sclerotization conspicuous 18

Lip sclerotization not conspicuous 19

18. Tail more than 2X anal body diameter.. magnicauda (Thorne, 1935

Tail less than 2X anal body diameter.....

..... brevicaudatus Hopper, 1959

19. Post-anal intestinal sac absent.. hüsingi Paetzold, 1958

Post-anal intestinal sac present 20

20. Tail more than 3X anal body diameter.. parvus Allen, 1955

Tail less than 3X anal body diameter.. maximus Allen, 1955

21. Lip region continuous with body contour 22

Lip region set off by a constriction or depression .. 34

22. Lip region with 2 annules .....nudus Allen, 1955

Lip region more than 2 annules 23

23. Lip sclerotization inconspicuous 24

Lip sclerotization conspicuous 32

24. Tail bearing 10-16 annules 25

Tail bearing more than 16 annules 26

25. Spermatheca present ..... mashhoodi Siddiqi & Basir, 1959

Spermatheca absent ..... clarus Allen, 1959

26. Spear less than 20 μ long 29

Spear 20 μ or more in length 27

27. Body finely striated 28

Body coarsely striated ..... coffeae Siddiqi & Basir, 1959

28. Tail end clavate ..... dactylurus Das, 1960

Tail end cylindroid ..... digitatus Das, 1960

29. Lip region bearing 5 annules ... striatus Allen, 1955

Lip region bearing less than 5 annules 30

30. Lip region with 3 annules, males absent .....

.....martini Fielding, 1956

Lip region with 3 or 4 annules, males abundant 31

31. Post-anal intestinal sac present... ewingi Hopper, 1959

Post-anal intestinal sac absent ... elegans n. sp.

32. Spear more than 20 μ long 33

Spear less than 20 μ long ..... manubriatus Litvinova, 1946

33. Spear not more than 31 μ long.. kegenicus Litvinova, 1946

Spear more than 31 μ long ..... galeatus Litvinova, 1946

34. Spear more than 20 μ long ..... cylindricus Cobb, 1913

Spear not more than 20 μ long 35

35. Lip region not marked by striae ... carissae n. sp.

Lip region marked by striae 36

36. Tail 3X anal body diameter long ... brassicae n. sp.

Tail 2X anal body diameter long ... latus Allen, 1955

37. Tail 2X anal body diameter long ... acutus Allen, 1955

Tail 3X anal body diameter long ... capitatus Allen, 1955

38. Annules extending around tail terminus 39

Annules not extending around tail terminus 44

39. Lip region set off from body contour 40

Lip region continuous with body contour 41

51. a = 30-33; spear 27-28 μ long ... lineatus Allen, 1955

    a = 50; spear 22 μ long ..... obscurisulcatus Andrássy, 195

52. Spear more than 55 μ long ..... superbus Allen, 1955

    Spear less than 55 μ long ..... conicus Allen, 1955

Other species: T. bucharius (Tulaganov, 1949) Tulaganov, 1954

T. caromatus (Tulaganov, 1949) Tulaganov, 1954

Tylenchorhynchus rugosus n. sp.

(Plate 2, Fig. A-G)

Measurements: 15 females: Length = 0.55-0.85 mm.; a = 22-29; b = 4.6-6; c = 12-17; V = 54.4-61%; spear = 13-15 μ.

6 males: Length = 0.56-0.64 mm.; a = 25-30.7; b = 4.6-5; c = 11.8-13; T = 40-60%.

10 larvae: Length = 0.41-0.53 mm.; a = 22-25; b = 4.4-5.5; c = 11-12.8.

Female (Holotype): Length = 0.85 mm.; a = 28.2; b = 5.9; c = 16.6; V = $^{36.3-54.8}{}^{-33}$%.

Body cylindrical, stout, tapering towards extremities. Cuticle marked by fine but well defined striae, about 1.2 μ apart, and by deep longitudinal striae, about 48 in number at mid-body. Lateral fields one-third as wide as body diameter, marked by 6 incisures. Lip region bluntly rounded, continuous with body contour, marked by five transverse striae, 7.5 μ wide by 3.5 μ high. En face head contour appearing slightly hexagonal, lips equal in size and form, papillae arranged as illustrated (Pl. 2, Fig. B). Cephalic frame-work only slightly sclerotized.

PLATE 2

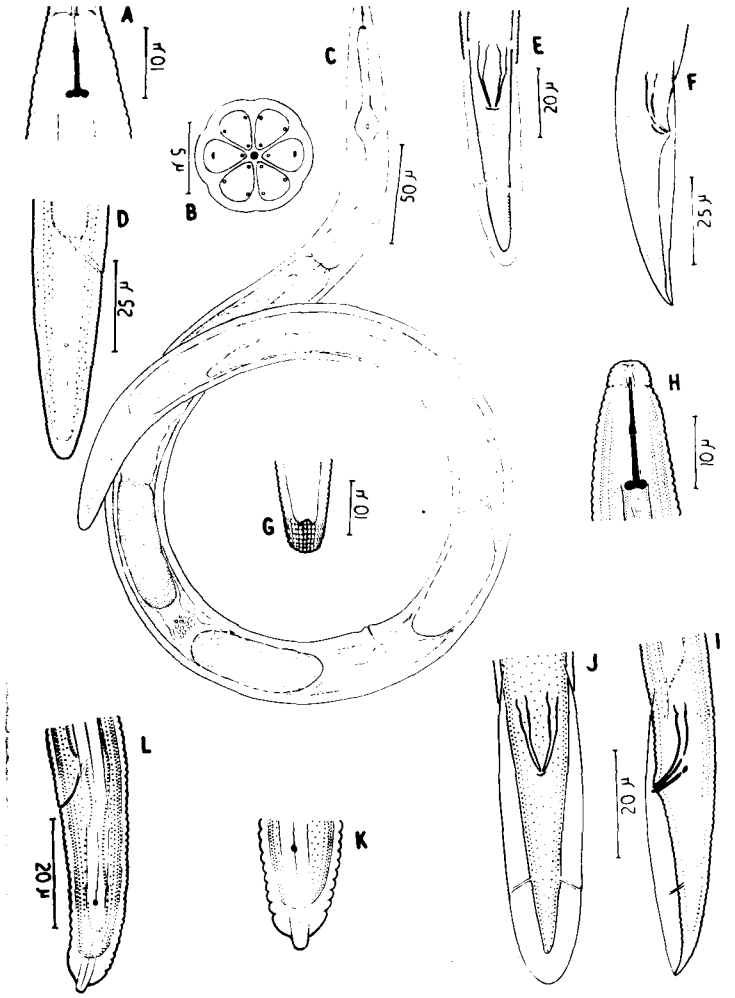


Plate 2. Figures A-G, Tylenchorhynchus rugosus. A. Head end of female; B. En face view; C. Female; D. Female tail; E. Male tail, ventral view; F. Male tail, lateral view; G. Cuticular pattern on caudal terminus of female. H-L, T. bivittatus. H. Head end of female; I. Male tail, lateral view; J. Male tail, ventral view; K. Tail end of female; L. Female tail.

Buccal spear short, stout, 14 μ long. Basal knobs of spear closely packed together, one-fourth as wide as body at that region. Orifice of dorsal oesophageal gland 2.5 μ behind spear base. Nerve ring at middle of isthmus. Hemizonid 3 body annules in extent. Excretory pore located at level of distal end of basal oesophageal bulb, 2 body annules posterior to hemizonid. Basal oesophageal bulb distinctly set off from intestine. Intestinal cells packed with granules of varying size.

Vulva a transverse slit, one-third of body width long. Spermatheca rounded, containing sperms. Ovaries paired, outstretched; oöcytes arranged in single file except for a few in region of multiplication. Uterine eggs 61-65 μ long by 22-23 μ broad. Rectum two-third of body diameter in length. Anus not prominent. Tail rather cylindrical, tapering regularly to a bluntly rounded terminus bearing striae around it (Pl. 2, Fig. G).

Male (Allotype): Length = 0.61 mm.; a = 30.7; b = 5; c = 12.5; T = 40%.

Transverse striae of body 1.1 μ apart. About 48 longitudinal striae present on middle of body. Minute deirids located at level of excretory pore. Lip region, oesophagus, and spear almost similar to those in holotype.

Testis single, outstretched; spermatocytes arranged in double rows except for a few just behind cap-cell which lie in single file. Spicula tylenchoid, 22 μ long. Gubernaculum simple, trough-shaped, 7.5 μ long. In ventral view, it appears as a disc about 4.5 μ in diameter, with a flat bottom and sides raised to an angle of 45 degrees. Bursa finely crenate, springing slightly

anterior to head of spicula and completely enveloping tail. Phasmids at about half-way down the tail. Latter slightly curved ventrally, with a pointed terminus.

Holotype: Female collected on 5th December, 1956; slide no. PN/T/2-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/2-002; other data same as for holotype.

Paratypes: About 30 females and 5 males; other data same as for holotype.

Type host: Collected around roots of Brassica oleracea L. (cawliflower).

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected from the following hosts in different localities of Uttar Pradesh: Solanum tuberosum L. (potato), Pisum sativum L. (pea), Brassica oleracea L. (cawliflower and cabbage), Mentha sp., and Orobanche sp.

Diagnosis and relationship: Tylenchorhynchus with the above general description and measurements. It can easily be distinguished by body bearing about 48 longitudinal striae on its middle, six incisures in the lateral fields, lip region bearing six annules and being continuous with the body contour, a short buccal spear not exceeding 15 μ in length, and annulations around tail terminus.

T. rugosus n. sp. is closely related to T. tessellatus Goodey, 1952, and T. quadrifer Andrássy, 1952. From the former it can be differentiated by having a continuous lip region,

a shorter buccal spear (13-15:18-20 μ), finer transverse striae of body, and smaller size of the spicula and gubernaculum; from the latter it differs in having a shorter buccal spear (13-15: 20.2-21.6 μ) and striae extending around tail terminus. It also shows some similarities with T. ornatus Allen, 1955, but can readily be distinguished from it by its shorter buccal spear (13-15:18-19 μ), annulated tail terminus and a greater number of the longitudinal striae (48:32 on mid-body).

Tylenchorhynchus bivittatus n. sp.

(Plate 2, Fig. H-L)

Measurements: 9 females: Length = 0.55-0.67 mm.; a = 32-38; b = 5.4-6.4; c = 16-19; V = 53-55.5%; spear = 16-17 μ.

2 males: Length = 0.58-0.61 mm.; a = 34-38; b = 5.5-6; c = 17-18; T = 46-52%; spear = 15.5-16 μ.

Female (Holotype): Length = 0.62 mm.; a = 36; b = 5.5; c = 18.8; V = $^{22.5-}_{54}{}^{-21.5}$%.

Body long, slender, tapering regularly at both ends. Transverse striae averaging 1 μ apart on mid-body. Lateral fields two-sevenths of body width, marked by 3 incisures making two longitudinal bands. Lip region marked off from body contour by a constriction, bearing 6 annules. Labial frame-work lightly sclerotized, its inner margins forming a short guide for the spear; the latter of medium strength, 16 μ long. Basal knobs of spear well developed, rounded in outline, closely packed together, 3.5 μ across. Orifice of dorsal oesophageal gland at 2 μ from spear base.

Corpus well developed, with a refractive valvular apparatus in centre. Nerve ring crossing isthmus anterior to its middle. Excretory pore located near base of isthmus. Hemizonid extending 4 body annules, situated 2 body annules anterior to excretory pore. Cardia prominent, spheroidal.

Ovaries paired, outstretched, with oöcytes in single file. Spheroidal spermatheca with sperms present in distal end of each uterus. Intestine with a post-anal extension; rectum less than one anal body diameter long. Tail regularly tapering, ending in a characteristic irregular terminus. Cuticle of lateral fields extending beyond tail terminus (Fig. K & L); phasmids located in the middle of lateral fields posterior to middle of tail, just on the middle incisure of lateral field which extends past phasmids.

Male (Allotype): Length = 0.61 mm.; a = 38; b = 6; c = 17.7; T = 46%.

Body, lip region and oesophagus similar to those of female. Lateral fields with 3 incisures, forming a pattern on tail as illustrated (Pl. 2, Fig. I). Testis single, outstretched; bursa arising from a level slightly anterior to head of spicula, completely enveloping tail. Spicula ventrally arcuate, distinctly cephalated, 17 μ long. Gubernaculum 8 μ long, rod-shaped in lateral view. Phasmids located posterior to middle of tail, extending into bursa.

Holotype: Female collected on 13th January, 1958; slide no. PN/T/2-003; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/2-004; other data same as for holotype.

Paratypes: 8 females and 1 male; other data same as for holotype.

Type host: Collected around roots of Citrus sinensis (L.) Osbeck.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Tylenchorhynchus with the above measurements and general description. It is distinguished from other species by the fine striae on the body, lateral fields bearing only 3 incisures, lip region set off from the body bearing 6 annules, buccal spear measuring 16-17 µ long, presence of post-anal extension of the intestine, an irregular caudal terminus and phasmids located behind middle of tail.

The species closest to T. bivittatus n. sp. are T. dubius (Bütschli, 1873) Filipjev, 1936, and T. parvus Allen, 1955. From these, it can easily be separated by the presence of only 3 incisures in the lateral fields and location of phasmids behind middle of tail.

Tylenchorhynchus indicus n. sp.

(Plate 3, Fig. E-K)

Measurements: 10 females: Length = 0.53-0.66 mm.; a = 24-29; b = 4.5-5.7; c = 12-16.5; V = 53-57%; spear = 14-15.5 µ.

4 males: Length = 0.56-0.7 mm.; a = 30-34; b = 4.6-5.8; c = 11-14.5; T = 60-65%; spear = 14-15 µ; spicula = 24-28 µ; gubernaculum = 10-12 µ.

Female (Holotype): Length = 0.65 mm.; a = 29; b = 5.4; c = 16; V = $^{31.3-}_{55}{}^{-23.8}$%.

Striae 1.1 μ apart on mid-body. Lateral fields about one-third as wide as body width, with 4 distinct incisures. Lip region broadly rounded, set off from body by a deep constriction, marked by 6 striae. Labial frame-work lightly sclerotized. In an en face view, lateral lips apparently smaller than sub-medians (Pl. 3, Fig. F). Spear weakly built, 15 μ long; basal knobs smoothly rounded, 2.5 μ across. Outlet of dorsal oesophageal gland 2.5 μ behind spear base. Basal oesophageal bulb set off from intestine. Excretory pore located near base of isthmus, 3 body annules posterior to hemizonid; the latter extending 4 body annules. Cardia compact, spheroidal.

Vulva transverse, slit-like; vagina one-third as long as body width; each uterus with irregular, elongate spermatheca; ovaries outstretched, opposed; uterine egg measuring 60 μ long by 17 μ broad.

Rectum about one-half anal body diameter long. Intestine with a post-anal extension. Phasmids distinct, located at one-fourth tail length down the anus. Tail conoid, tapering to a bluntly rounded, striated terminus.

Male (Allotype): Length = 0.58 mm.; a = 30.6; b = 5; c = 12.3; T = 64%.

Buccal spear 14 μ long; basal knobs 2.5 μ across. Testis single, outstretched. Behind cap-cell, spermatocytes arranged in single file up to middle of region of spermatogenesis beyond which forming double rows. Spicula tylenchoid, 26 μ in length. Gubernaculum

11 μ long; its proximal half flat, linear, slightly bent upwards, with distal portion forming a trough-shaped channel with raised sides. Phasmids flask-shaped, forming false ribs supporting bursa, at one-third of tail length from anus. Tail sharply pointed, ventrally arcuate.

Holotype: Female collected on 19th March, 1957; slide no. PN/T/2-005; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male collected on 9th February, 1957; slide no. PN/T/2-006; other data same as for holotype.

Paratypes: 9 females and 3 males; other data same as for holotype.

Type host: Saccharum officinarum L. (sugarcane).

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected around roots of Saccharum officinarum L., Cajanus indicus Spr., and Citrus limon (L.) Burm. in Aligarh (U. P.); Citrus limon (L.) Burm. in Banda (U. P.).

Diagnosis and relationship: Tylenchorhynchus with the above measurements and general description, distinctive because of a broad, rounded lip region which is distinctly set off from body contour and bears 7 annules; 4 incisures in lateral fields; a short buccal stylet measuring 14-15.5 μ long; a post-anal extension of the intestine; a conoid tail with striations around terminus; and the presence of a characteristic gubernaculum in male.

T. indicus n. sp. comes closest to T. dubius (Bütschli, 1873) Filipjev, 1936, from which it can be differentiated by its smaller

buccal stylet (18-19 μ long in T. dubius), smaller and closely packed basal knobs of the spear, and the characteristic gubernaculum in male. It also shows some resemblance with T. bivittatus n. sp. from which it is distinguished by having 4 incisures in lateral fields as compared to 3 in the latter species and in having striations around caudal terminus.

Tylenchorhynchus elegans n. sp.

(Plate 3, Fig. A-D)

Measurements: 10 females: Length = 0.56-0.7 mm.; a = 25-29; b = 4.4-5.2; c = 14.5-16; V = 54-55%; spear = 15-17 μ.

5 males: Length = 0.55-0.7 mm.; a = 25-33; b = 4.8-5.5; c = 14.6-18; T = 53-65%; spear = 15-16 μ.

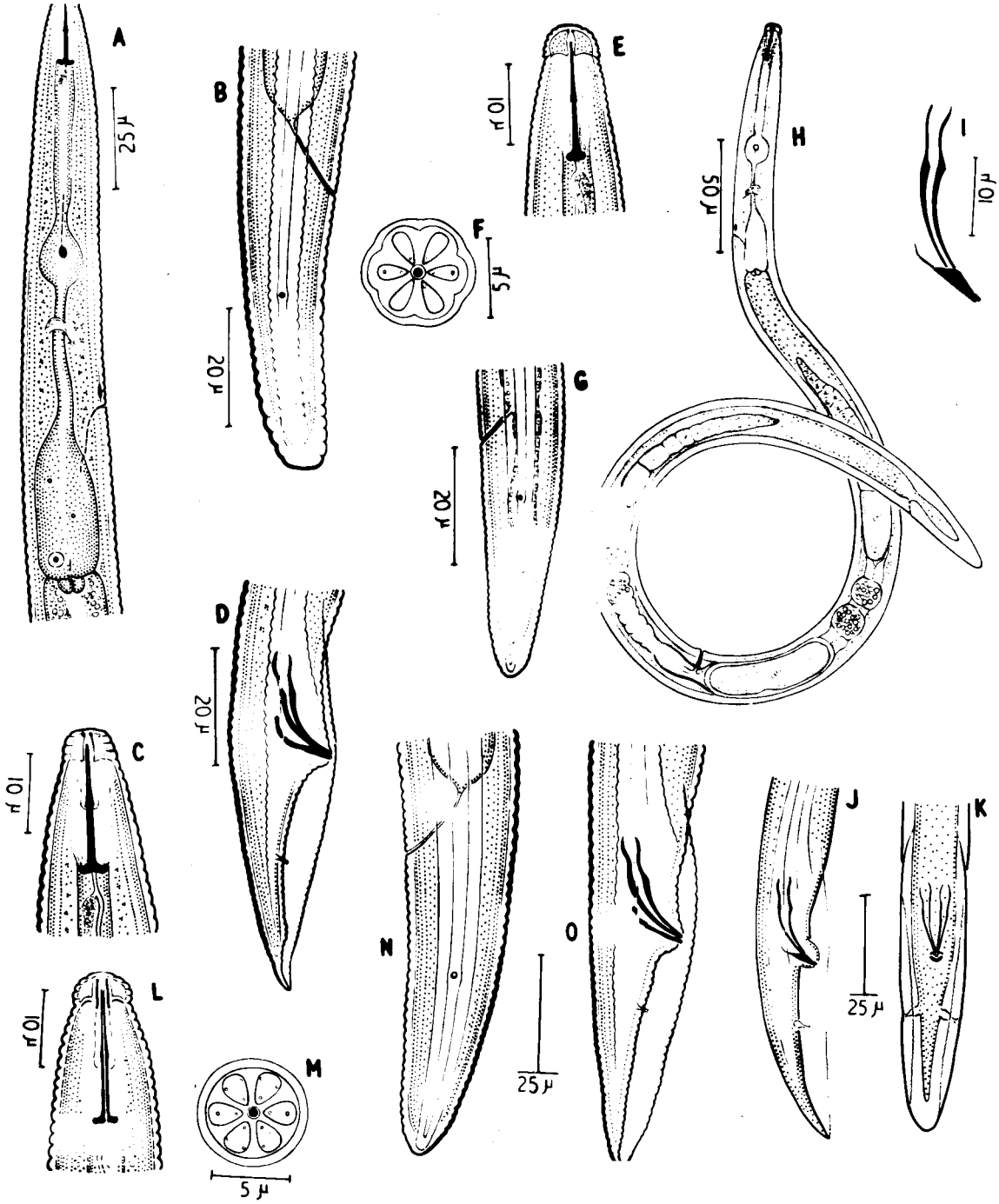
3 larvae: Length = 0.4-0.49 mm.; a = 23-25.8; b = 4.5-4.8; c = 12-13.5; spear = 12-13.4 μ.

Female (Holotype): Length = 0.7 mm.; a = 26; b = 4.8; c = 15.4; V = $^{31.3-}54.8^{-33.3}$%.

Striae 2.2 μ apart on mid-body. Lateral fields two-sevenths of corresponding body width, marked by 4 incisures. Lip region 6.5 μ wide by 3.5 μ high, almost continuous with body contour, marked by 3 coarse striae. Cephalic frame-work inconspicuously sclerotized. Deirids minute, located slightly behind level of excretory pore. Buccal spear of medium strength, 17 μ long; basal knobs well separated from each other. Orifice of dorsal oesophageal gland 2.5 μ behind spear base. Basal oesophageal bulb set off from intestine. Excretory pore at level of distal end

Plate 3. Figures A-D, Tylenchorhynchus elegans. A. Oesophageal region of female; B. Female tail; C. Head end of female; D. Male tail. E-K, T. indicus. E. Head end of female; F. En face view; G. Female tail; H. Female; I. Spicule and gubernaculum; J. Male tail; K. Male tail, ventral view. L-O, T. brassicae. L. Head end of female; M. En face view; N. Female tail; O. Male tail.

PLATE 3


A
25 µ
B
20 µ
C
10 µ
D
20 µ
E
10 µ
F
5 µ
G
20 µ
H
50 µ
I
10 µ
J
25 µ
K
L
10 µ
M
5 µ
N
O
25 µ

of basal oesophageal bulb, 1 body annule posterior to hemizonid which is 2 body annules long. Cardia well developed. Intestinal cells packed with refractive food globules.

Vulva a transverse slit, with slightly raised lips. Spermathecae not observed. Ovaries paired, outstretched in opposite directions. Tail sub-cylindrical, with a broadly rounded terminus. Latter without striations around it. Phasmids located at about two-fifths of tail length down the anus. Single uterine egg measuring 73 μ long by 22 μ broad.

Male (Allotype): Length = 0.6 mm.; a = 30; b = 5.2; c = 14.6; T = 65%.

Body similar to that of female. Striae 1.8 μ apart at middle of body. Buccal spear 15 μ long. Testis single, outstretched. Sperms 3 μ in diameter. Spicules tylenchoid, 20 μ long. Gubernaculum fairly large, 12.5 μ in length. Bursa large, coarsely crenate. Phasmids slightly anterior to middle of tail, partially extending into bursa. Tail sharply tapering, ventrally arcuate.

Holotype: Female collected on 8th December, 1956; slide no. PN/T/2-007; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/2-008; other data same as for holotype.

Paratypes: 9 females and 4 males; other data same as for holotype.

Type host: Collected around roots of Saccharum officinarum L.

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this

species have been collected around roots of Saccharum officinarum L. and Cyperus rotundus L. in Aligarh, Banda (U. P.); Cynodon dactylon Pers. in Aligarh, Banda, Pilibhit (U. P.) and Jabalpur (M. P.); Oryza sativa L. in Aligarh (U. P.).

Diagnosis and relationship: Tylenchorhynchus with the above measurements and general description. It can be distinguished by its lip region bearing 3 striae and being continuous with body contour, coarse striae on body, 4 incisures in lateral fields, 15-17 μ long buccal spear, a cylindroid tail, and a broadly rounded, untriated terminus of tail.

T. elegans n. sp. resembles T. nudus Allen, 1955, T. martini Fielding, 1956, T. carissae n. sp., and T. striatus Allen, 1955. From the first of these it differs in having 3 striae on lip region (only one in T. nudus), a smaller spear (15-17:19-23 μ), and the caudal terminus being continuous with the tail contour. From T. martini it differs in having a smaller buccal spear, 3 striae on lip region, larger size of eggs, and abundance of males. It differs from T. carissae n. sp. in having a continuous lip region, distinct striae on head, and smaller spear (15-17:19-21 μ). It can be separated from T. striatus in having 3 striae on head (4-5 in T. striatus), absence of spermatheca, and a broadly rounded caudal terminus.

Tylenchorhynchus brassicae n. sp.

(Plate 3, Fig. L-O)

Measurements: 10 females: Length = 0.58-0.72 mm.; a = 26-35;

b = 5-6; c = 14-17; V = 52-58%; spear = 16-17 μ.

8 males: Length = 0.53-0.58 mm.; a = 29-35; b = 4.8-5.8; c = 15-17; T = 47-60%.

Female (Holotype): Striae 2 μ apart on mid-body, completely interrupted by lateral fields occupying a space one-third as wide as body width and marked by 4 incisures. Lip region rounded, set off from body by a constriction, marked by 4 striae. Labial frame-work moderately sclerotized. Buccal spear of medium strength, 17 μ long. Anterior margins of basal knobs of spear slightly directed forward. Orifice of dorsal oesophageal gland 3 μ behind spear base. Excretory pore at base of isthmus, 2 body annules posterior to hemizonid which extends 3 body annules. Basal oesophageal bulb sac-like, set off from intestine. Cardia large, hemispherical.

Vulva about one-fourth body width long. Spermathecae present. Ovaries paired, outstretched in opposite directions, with oöcytes arranged in single file; distal end of anterior ovary forming a double flexure. Uterine egg in paratype 60 μ long by 21 μ broad. Tail about 3 anal body diameters long, conoid, regularly tapering, ending in a large, unstriated terminus. Phasmids situated a little anterior to middle of tail.

Male (Allotype): Length = 0.62 mm.; a = 31; b = 5.8; c = 15; T = 58%.

Head rounded, set off from body by a deep constriction, bearing 5 annules. Buccal spear 15 μ long. Testis single, outstretched. Spicula distinctly cephalated, 21 μ in length. Gubernaculum 10 μ long, with tip of its distal end rounded.

Bursa large, with crenate margins, arising from a level about one-and-a-half spicula lengths anterior to cloaca and completely enveloping tail. Phasmids forming false ribs, partially supporting bursa, located at about one-third down the tail.

Holotype: Female collected on 4th February, 1957; slide no. PN/T/2-009; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male collected on 8th February, 1957; slide no. PN/T/2-010; other data same as for holotype.

Paratypes: 9 females and 7 males; other data same as for holotype.

Type host: Brassica oleracea L. (cabbage).

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected in the State of U. P. from soil about roots of Brassica oleracea L. (cabbage and cawliflower), in Aligarh, Meerut, Banda and around grass roots in Aligarh.

Diagnosis and relationship: Tylenchorhynchus with the above measurements and general description. It is distinguished by the coarse striae on body, broad lateral fields with four incisures, a well set off and rounded lip region bearing 5 annules, presence of a spermatheca in each uterus, a conoid tail which is about 3 anal body diameters long, and an unstriated caudal terminus.

T. brassicae n. sp. is closest to T. latus Allen, 1955, and T. cylindricus Cobb, 1913. It differs from T. latus in having a rounded lip region bearing lesser number of annules (6 in the latter species), presence of a spermatheca in each uterus, a longer tail (2 anal body diameters long in T. latus),

and abundance of males; and from T. cylindricus it can be differentiated by its smaller body-size, lesser extent of labial sclerotization, and a shorter buccal spear which is 16-17 μ long as compared to 24-27 μ of T. cylindricus.

Tylenchorhynchus carissae n. sp.

(Plate 4, Fig. A-C)

Measurements: 5 females: Length = 0.61-0.79 mm.; a = 26-28; b = 4.9-5.5; c = 14.5-16; V = 55-57%; spear = 19-21 μ.

5 males: Length = 0.59-0.7 mm.; a = 28-32; b = 5-6; c = 15.4-16.5; T = 58-65%; spear = 19-20 μ; spicula = 22-24 μ; gubernaculum = 13-15 μ.

1 larva: Length = 0.5 mm.; a = 28; b = 4.3; c = 12.8; spear = 18 μ.

Female (Holotype): Length = 0.79 mm.; a = 27; b = 5.5; c = 16.4; V = $^{24.4-}_{56.9}{}^{-21.7}$%.

Body assuming a slightly ventrally arcuate position on death. Lateral fields with 4 incisures, one-fourth as wide as body width; outer incisures distinctly crenate. Cuticle striae coarse, 2.6 μ apart on mid-body. Lip region conoid-rounded, slightly set off from body contour by narrowing of the neck contour; transverse striae on lip region not discernible. Labial frame-work lightly sclerotized. Spear slender, 20 μ long. Basal knobs of spear rather small, almost rounded, with anterior margins slightly flattened, closely packed together, 3.3 μ across, measuring about one-fourth as wide as corresponding body diameter. Orifice of dorsal oesophageal gland 2.5 μ behind spear base. Basal oesophageal bulb distinctly set off from intestine.

PLATE 4

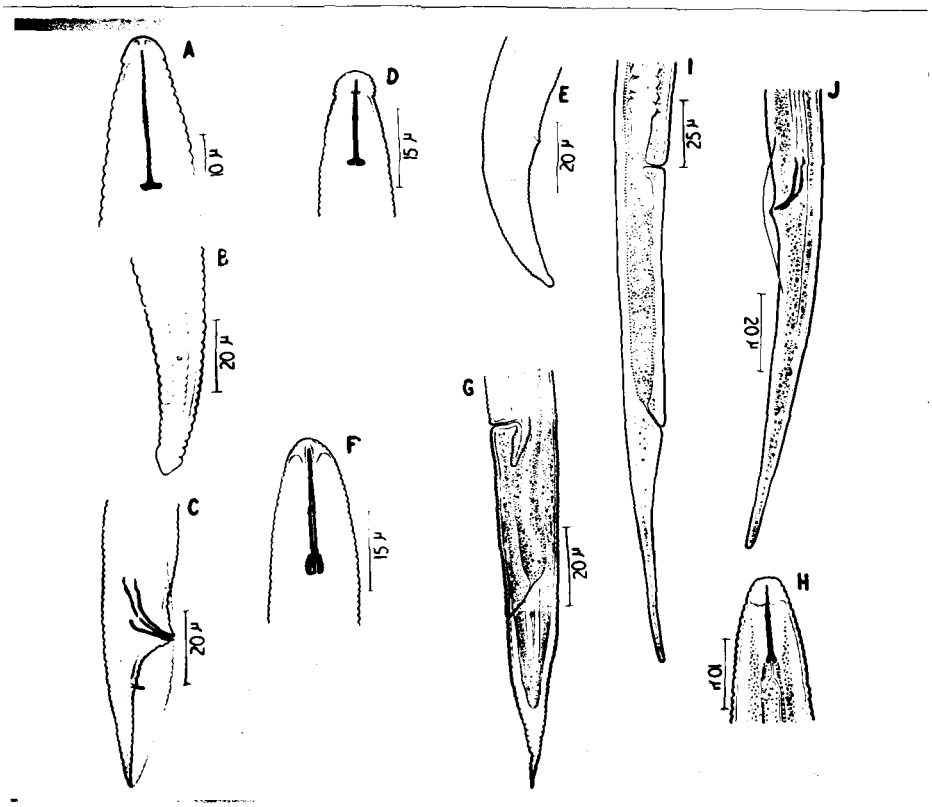


Plate 4. Figures A-C, Tylenchorhynchus carissae. A. Anterior end of female; B. Female tail; C. Male tail; D-E, T. capitatus. D. Anterior end of female; E. Female tail; F-G, Hoplotylus tenuicadatus. F. Anterior end of female; G. Posterior end of female. H-J, Boleodorus citri. H. Anterior end of female; I. Posterior end of female; J. Male tail.

Excretory pore near distal end of basal oesophageal bulb. Hemizonid poorly developed, just anterior to excretory pore. Cardia small, hemispheroidal.

Vulva transverse, with raised lips. Spermatheca absent. Ovaries paired, outstretched; oöcytes in single file. Tail sub-cylindrical, with less than 20 annules, ending in a large, unstriated, conoid-rounded terminus which is set off from tail contour. Lateral fields ending just before caudal terminus; inner incisures not coalescing behind level of phasmids which are located anterior to middle of tail.

Male (Allotype): Length = 0.65 mm.; a = 29.5; b = 5.2; c = 16; T = 60%.

Body more ventrally arcuate on death than that of female. Striae 2 μ apart on mid-body. Testis single, outstretched; spermatocytes mostly arranged in double rows. Spicula arcuate, cephalated, 23 μ long. Gubernaculum long, slightly curved in the proximal half, 14 μ in length. Bursa large, crenate, enveloping entire tail. Latter conoid, straight. Phasmids anterior to middle of tail.

Holotype: Female collected on 4th February, 1959; slide no. PN/T/2-011; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/2-012; other data same as for holotype.

Type host: Carissa sp. growing in hilly regions.

Type locality: Karwi, Banda District (U. P.), India.

Diagnosis and relationship: Tylenchorhynchus with the

above measurements and general description. It is distinguished by its lip region which is plain, not marked by striae, set off from the body by a depression; lateral fields with four incisures; coarse striae on body; 20 μ long buccal spear bearing closely packed basal knobs which are one-fourth as wide as body diameter at that region; a sub-cylindrical tail ending in a large, unstriated terminus; and the phasmids located anterior to middle of tail.

It comes close to T. nudus Allen, 1955, T. elegans n. sp., and T. ewingi Hopper, 1959. From the first of these it differs in having a conoid-rounded, set off lip region which is devoid of transverse striae and closely packed almost rounded, small basal knobs of the spear; from the second, it can be differentiated by having a set off, unstriated lip region (3 striae on head in T. elegans), a longer spear and the tail terminus being large and set off from tail contour; from the last, the present species can be separated by the absence of transverse striae on head and a post-anal intestinal sac and the shape of the caudal terminus.

Tylenchorhynchus capitatus Allen, 1955

Syn: Tylenchorhynchus acti Hopper, 1955

(Plate 4, Fig. D-E)

This species was originally described by Allen (1955) from specimens collected around pear roots in California, U. S. A. Later, in 1959, Hopper described a new species collected around roots of Hibiscus esculentus L. in Alabama, U. S. A. which he named T. acti. After comparing his specimens with the paratypes

of Allen's T. capitatus, Hopper concluded that T. acti should be reduced to a synonym of T. capitatus Allen, 1955 (personal correspondance).

This species has recently been collected at Chiavari, Italy, around roots of Phoenix dactylifera and some additional information about its morphology has been added by Loof (1959). The author has collected this species around grass roots at Bhowali, Nainital District (U. P.), India (elevation 5,500 feet). It is apparently the first record of this species from Asia. The description of this species conforms closely with that given by Allen (1955), Hopper (1959) and Loof (1959). Important characters of the species have been mentioned below. It is interesting that the author could find an egg in one of the females. Unlike most of the other Tylenchorhynchus spp., T. capitatus has a comparatively smaller-sized egg which measures 25 µ long by 14 µ broad.

Female: Measurements: 8 females. Length = 0.7-0.81 mm; a = 30-35; b = 4.5-5.5; c = 15-17; V = 54-56.4%; spear = 16-17 µ.

Body assuming a spiral form on death. Lateral fields one-third as wide as body, marked by 5 incisures. Lip region set off from body contour, with 8 striae. Spear with rounded basal knobs. Hemizonid indistinct. Spermatheca absent. Tail ventrally arcuate, with an enlarged terminus. Phasmids anterior to middle of tail. Males not found.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Genus Ditylenchus Filipjev, 1934

Diagnosis: Tylenchinae: Head smoothly rounded, without transverse striae. Lateral fields marked by 4-6 incisures. Phasmids usually located on the posterior third of tail. Ovary single, prodelphic. Oöcytes in one or two rows, never arranged about a rachis. Spermatheca absent. Bursa usually ad-anal, extending from one-fourth to three-fourth of tail length. Tail in both sexes elongate, conoid, with acute to rounded terminus.

Type species: Ditylenchus dipsaci (Kühn, 1857) Filipjev, 1936.

Key to species of Ditylenchus

(Modified after Hopper and Cairns, 1959)

1. Tail terminus acute or sub-acute 2
   Tail terminus obtusely rounded 19
2. a = 32-60 3
   a = 20-31 10
3. Bursa rudimentary ... darbouxi (Cotte, 1912) Filipjev, 1936
   Bursa not rudimentary 4
4. Tail end sickle-shaped ... drepanocercus Goodey, 1953
   Tail end not sickle-shaped 5
5. Oesophagus well developed; gubernaculum in profile thin, but long ..... intermedius (de Man, 1880) Filipjev, 1936
   Oesophagus in adult form, especially in males, is weak, not strongly muscular; gubernaculum short and thick.... 6

6. Bursa ending a short distance in front of caudal terminus 7

Bursa quite wrapping in the tail ..... procerca (Bally and Reydon, 1931) Filipjev, 1936

7. Lateral fields with 4 incisures; tail terminus acute ... . dipsaci (Kühn, 1857) Filipjev, 1936

Lateral fields with 6 incisures; tail terminus finely rounded 8

8. Post-uterine sac 2½ vulvar body widths..... ..... destructor Thorne, 1945

Post-uterine sac less than 2½ vulvar body widths 9

9. Post-uterine sac extending half the vulva-anus distance ..... myceliophagus Goodey, 1958

Post-uterine sac extending one-fourth to one-third vulva-anus distance.. triformis Hirschmann, 1955

10. Bursa not quite wrapping in the tail 11

Bursa quite wrapping in the tail 18

11. Vulva at 75-85% 12

Vulva at 86-96% 15

12. Spicula with thick sheath ..radicicola (Greeff, 1872) Filipjev, 1936

Spicula not provided with thick sheath 13

13. Body less than 0.65 mm. ..... nanus n. sp.

Body more than 0.65 mm. 14

14. Spicula head hardly set off; male tail about 2 1/3 anal body width long.. phyllobius (Thorne, 1934) Filipjev, 1936

Spicula head distinctly set off; male tail about 3½ anal body width long... angustus (Butler, 1913) Filipjev, 1936

15. Vulva at 96%.... pustulicola (Thorne, 1934) Filipjev, 1936

Vulva at 86-90% 16

16. Body less than 1 cm..... arboricolus (Cobb, 1922) Filipjev, 1936

Body over 1 cm. 17

17. Post-uterine sac absent ....graminophila (Goodey, 1933) Filipjev, 1936

Post-uterine sac present .. balsamophilus (Thorne, 1926) Filipjev, 1936

18. Median oesophageal bulb inconspicuous ..... durus (Cobb, 1927) Filipjev, 1936

Median oesophageal bulb conspicuous ..... pinophila (Thorne, 1935) Filipjev, 1936

19. Tail 1½ anal body diameters long 20

Tail 2-3 anal body diameters long 21

20. Spear 1/10 of oesophageal length; lip region not distinctly set off ..... major (Fuchs, 1914) Filipjev, 1936

Spear 1/15 of oesophageal length; lip region distinctly set off from body .. gallica (Steiner, 1935) Filipjev, 1936

21. Spear 1/20 of oesophageal length .... dendrophilus (Marcinovsky, 1909) Filipjev, 1936

Spear 1/10-1/12 of oesophageal length 22

22. Tail truncated ..... ortus Fuchs, 1938

Tail not truncated ..... zeae n. sp.

Other species: D. askenasyi (Bütschli, 1873) Goodey, 1951

D. brenani (Goodey, 1945) Goodey, 1951

D. sycobius (Cotte, 1920) Filipjev, 1936

D. brevicauda (Micoletzky, 1925) Filipjev, 1936

D. misellus Andrássy, 1958

Ditylenchus nanus n. sp.

(Plate 5, Fig. A-E)

Measurements: 6 females: Length = 0.51-0.63 mm.; a = 27.4-32.4; b = 4.5-7.7; c = 17-18.8; V = $^{35-26-}81.5-85.4^{-6-9}$%; spear = 7-7.5 µ.

3 males: Length = 0.37-0.43 mm.; a = 32-35.5; b = 4.3-4.5; c = 15-16.3; T = 41-43%; spear = 7-7.5 µ; spicula = 14-15 µ.

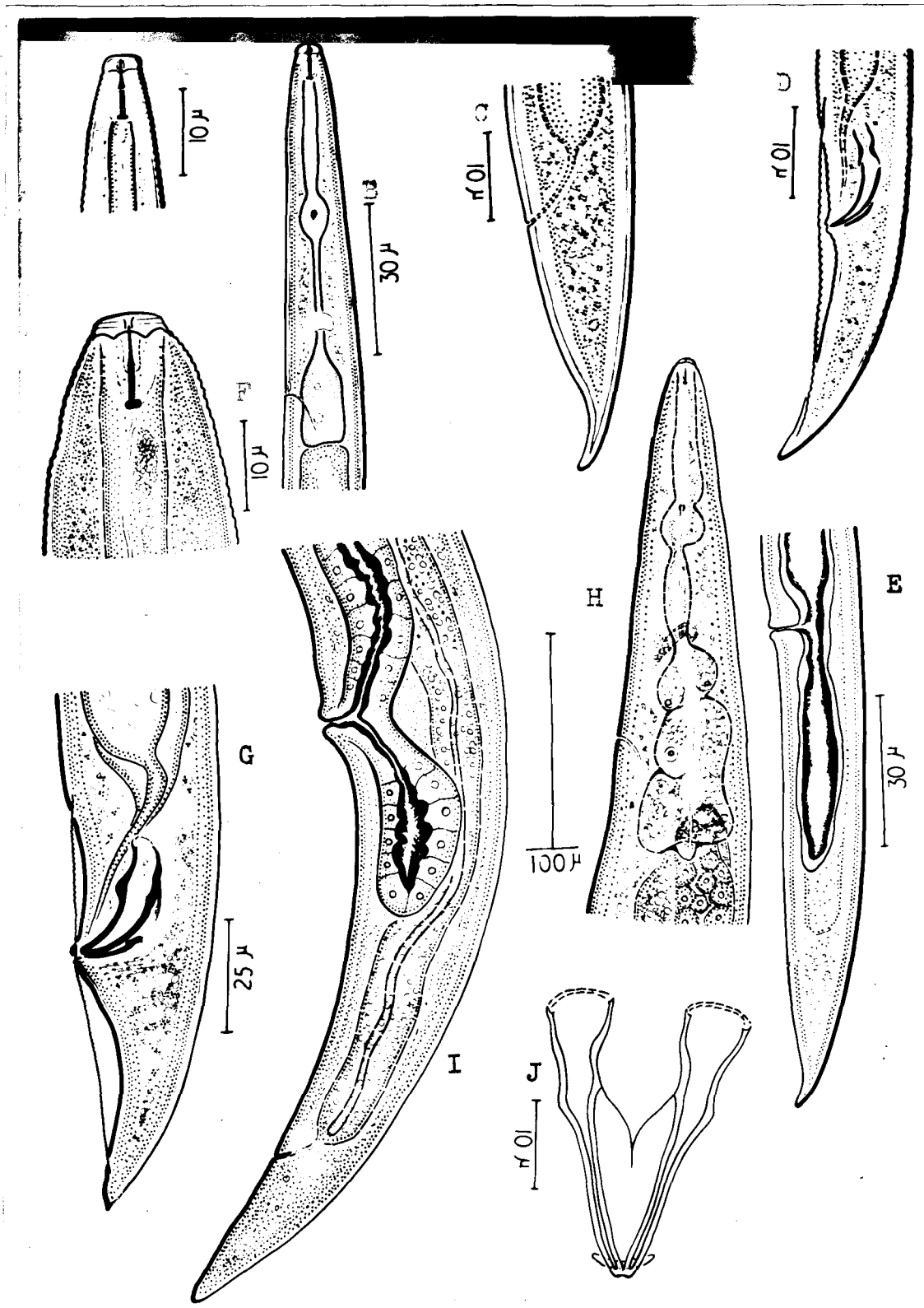
Female (Holotype): Length = 0.52 mm.; a = 27.4; b = 6.4; c = 18.8; V = $^{35-}81.5^{-9}$%.

Body stout and cylindrical, regularly tapering towards either extremities. Striae fine, 1 µ apart. Lip region set off from body contour. Buccal spear weak, 7.5 µ in length; basal knobs small, with outer margins smoothly rounded. Orifice of dorsal oesophageal gland located close to spear base. Median oesophageal bulb oval, with refractive, valvular apparatus in centre. Isthmus slender, enveloped by nerve ring posterior to its middle. Basal oesophageal bulb set off from intestine. Excretory pore located 14 µ behind level of nerve ring. Hemizonid 3 body annules long, located just anterior to excretory pore.

Vulva a transverse slit, with prominent lips. Vagina

Plate 5. Figures A-E, Ditylenchus nanus. A. Head end of female; B. Oesophageal region of female; C. Female tail; D. Male tail; E. Posterior end of female. F-J, Anguina tritici. F. Head end of female; G. Male tail; H. Oesophageal region of female; I. Posterior end of female; J. Spicules in ventral view.

PLATE 5



muscular, one-third the vulvar body width long. Ovary single, outstretched; oöcytes arranged in single row. Post-uterine sac long, extending up to five-seventh the vulva-anus distance. Rectum short, indistinct. Anus also indistinct. Tail tapering regularly up to its middle then sharply narrowing down and becoming ventrally arcuate. Caudal terminus bluntly rounded.

Male (Allotype): Length = 0.43 mm.; a = 32.4; b = 4.5; c = 15; T = 41.5%.

Body essentially similar to that of female. Testis single, outstretched; spermatocytes arranged in a single line. Spicules paired, similar, ventrally arcuate, cephalated, 14 μ in length. Gubernaculum linear, 5 μ long. Bursa crenate, springing from a level anterior to head of spicula and ending slightly before caudal terminus. Cloaca located on a distinct protuberance of body. Tail ventrally arcuate, regularly tapering, ending in a smoothly rounded terminus.

Holotype: Female collected on 8th January, 1958; slide no. PN/T/3-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/3-002; other data same as for holotype.

Type host: Psidium guayava L. (guava tree).

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Ditylenchus with the above measurements and general description. It is distinctive because of its short and stout body, 7-7.5 μ long spear, vulva located at 81.5-85.4 per cent of the body length from anterior end,

comparatively larger post-uterine branch, irregularly tapering female tail, and length of spicula in male.

D. nanus n. sp. is related to D. procerca (Bally and Reydon, 1930) Filipjev, 1936, but can be distinguished from it in having a less slender body, a longer post-uterine sac, a shorter female tail, and bursa not quite wrapping in the tail.

Ditylenchus zeae n. sp.

(Plate 6, Fig. A-E)

Measurements: 2 females: Length = 0.58-0.7 mm.; a = 28-33; b = 5.2-7; c = 17-20; V = 83-84.5; spear = 8-9 μ.

2 males: Length = 0.6-0.67 mm.; a = 33-38; b = 6.6-6.8; c = 17-18.5; T = 51-56%; spear = 9 μ; spicula = 17 μ.

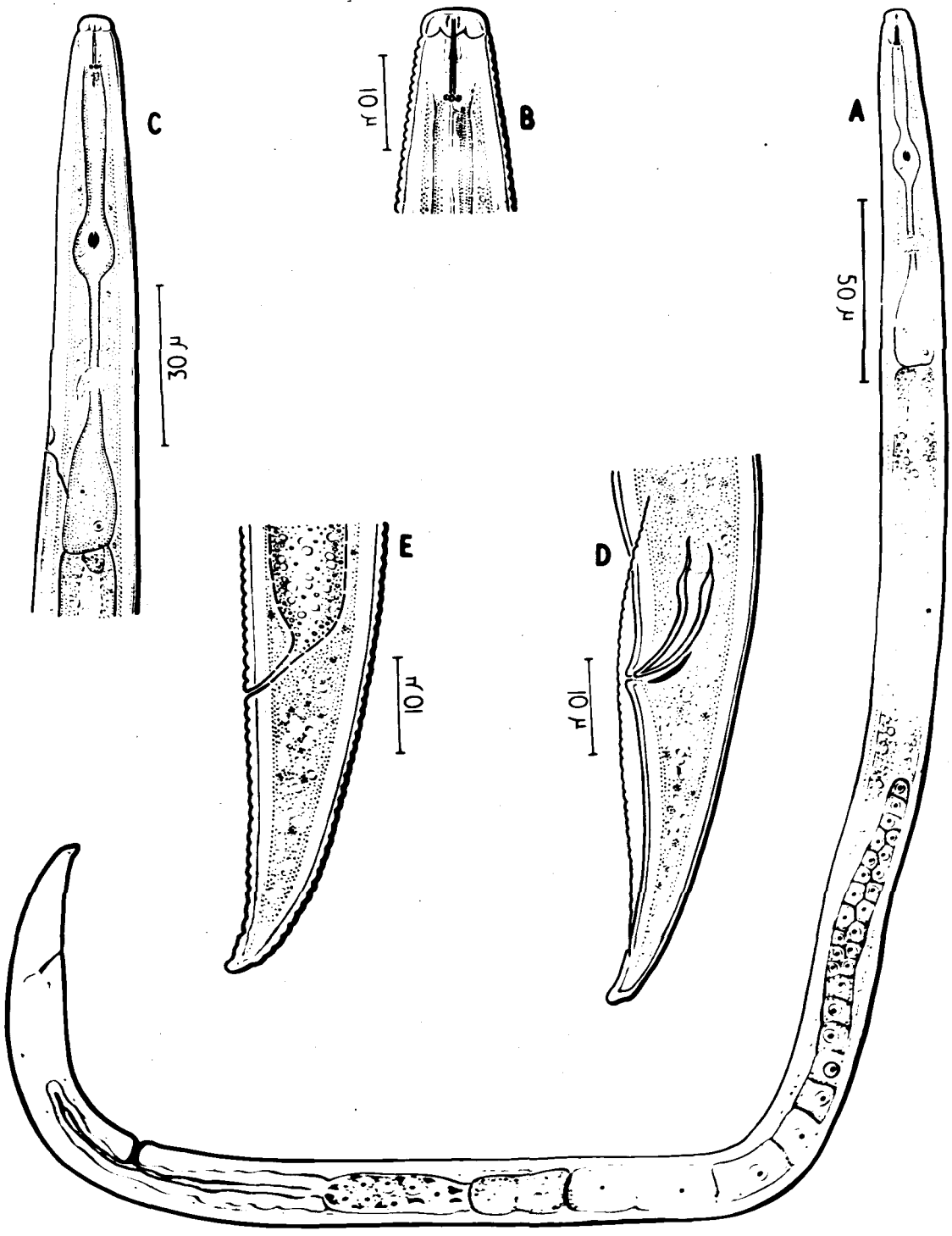
Female (Holotype): Length = 0.58 mm.; a = 33; b = 5.2; c = 20; V = $^{47.8-}_{83}{}^{-5.5}$%.

Body striae fine, interrupted on lateral sides by fields two-fifths as wide as body diameter. Lip region smoothly rounded set off from body contour. Spear 9 μ in length. Basal knobs of spear small, rounded. Orifice of dorsal oesophageal gland very close to spear base. Nerve ring near middle of isthmus, anterior to excretory pore. Hemizonid 3 body annules long, situated 1 body annule anterior to excretory pore. Basal oesophageal bulb set off from intestine.

Ovary single, outstretched; öocytes arranged in single file. Post-vulvar uterine branch extending halfway the vulva-anus distance. Rectum short; anus distinct. Phasmids located at

Plate 6. Figures A-E, Ditylenchus zeae. A. Female; B. Anterior end of female; C. Oesophageal region of female; D. Male tail; E. Female tail.

PLATE 6



beginning of posterior third of tail. Latter conoid, tapering to a broadly-rounded terminus.

Male (Allotype): Length = 0.67 mm.; a = 38; b = 6.8; c = 18.5; T = 56%.

Testis single, outstretched; spermatocytes arranged in double rows except for a few near its tip. Spermatozoa averaging 7 μ in diameter. Bursa sub-caudal, springing from a level slightly anterior to head of spicula. Spicula paired, ventrally arcuate, cephalated, 17 μ long. Gubernaculum saucer-shaped, 6 μ in length .

Holotype: Female collected on 3rd January, 1957; slide no. PN/T/3-003; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/T/3-004; other data same as for holotype.

Type host: Endo-parasitic in roots of Zea mays L. (maize).

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Ditylenchus with the above measurements and general description. D. zeae n. sp. is distinguished from other species of the genus by its short body-size, 9 μ long buccal spear, vulva located at 83-84.5 per cent of body from anterior end, uterine sac extending halfway the vulva-anus distance, a conoid tail with broadly rounded terminus in both the sexes and size of the spicula in male.

D. zeae n. sp. is close to D. ortus Fuchs, 1938, D. phyllobius (Thorne, 1934) Filipjev, 1936, and D. brevicauda (Micoletzky, 1925) Filipjev, 1936. From the first of these

it differs in its smaller size of body, more anteriorly placed vulva, and tail having a broadly rounded terminus (truncated in D. ortus); from the second it is differentiated by its shorter body length, presence of well developed corpus, and a rounded caudal terminus (acute in D. phyllobius); and from the third it can be distinguished by its shorter tail, a broadly rounded caudal terminus, and a longer post-uterine sac.

Ditylenchus myceliophagus Goodey, 1958

(Plate 7, Fig. A-G)

This species was described by J. B. Goodey (1958) as attacking the cultivated mushroom, Agaricus hortensis Cooke, in Britain, Netherlands and U. S. A. Das (1960) described a single female specimen from Sorghum vulgare collected in Hyderabad (A. P.). The author collected both male and female specimens of this species from rotting roots of sugarcane, Saccharum officinarum L., at Aligarh (U. P.), India. It is presumed that the nematodes were feeding on the associated fungi.

The specimens collected by the author closely conform with those described by Goodey (1958). It is illustrated hereunder with suitable diagrams and measurements of 10 females and 4 males have also been given.

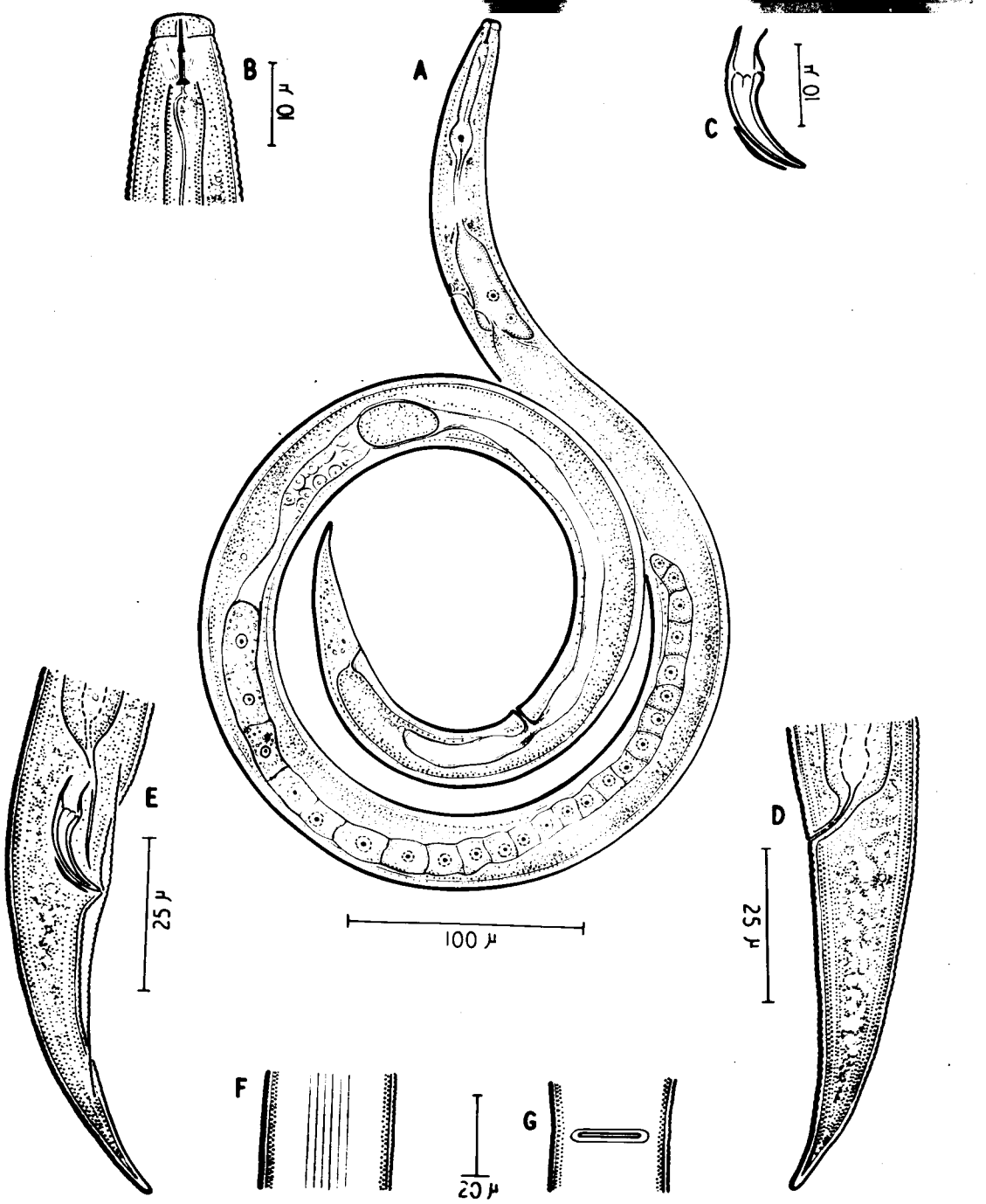
10 females: Length = 0.84-1.08 mm.; a = 26-35; b = 7-8; c = 14-19; V = 81-84%; spear = 7.5-8.5 μ.

4 males: Length = 0.7-0.85 mm.; a = 31-37; b = 6.8-7.1; c = 13-15; spicula = 21-23 μ; gubernaculum = 7-9 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Plate 7. Figures A-G, Ditylenchus myceliophagus. A. Female; B. Head end of female; C. Spicule and gubernaculum; D. Female tail; E. Male tail; F. Lateral field; G. Vulva in ventral view.

PLATE 7



Genus Anguina Scopoli, 1777

Syn: Anguillulina Gerv. & v. Ben., 1859 in part
Tylenchus Bastian, 1865 in part

Diagnosis: Tylenchinae: Comparatively large and robust forms. Female body generally spirally coiled. Lateral fields as plain bands. Spear small. Isthmus somewhat lobed. Basal oesophageal bulb swollen, frequently assuming an irregular form. Ovary single, anteriorly reflexed once or twice. Oöcytes in multiple rows, arranged about a rachis. Spicula paired, heavy, with rather wide blades. Testis single, with spermatocytes developing in multiple rows and arranged about a rachis. Bursa enveloping almost entire tail. Parasites of seeds and stems of plants.

Type species: Anguina tritici (Steinbuch, 1799) Filipjev, 1936.

Anguina tritici (Steinbuch, 1799) Filipjev, 1936

(Plate 5, Fig. F-J)

Syn: Vibrio tritici Steinbuch, 1799, Bauer, 1823
Rhabditis tritici Dujardin, 1845
Anguillula graminearum Diesing, 1851 in part
Anguillulina tritici (Steinbuch, 1799) Gerv. & v. Ben., 1859
Tylenchus tritici (Steinbuch, 1799) Bastian, 1865
Anguillula scandens Schneider, 1866

Anguina tritici, an obligate, gall-forming parasite of grains of wheat and other grasses, is almost cosmopolitan in distribution. The author has collected large numbers of specimens from wheat cockles from many localities in Aligarh, Banda, Kanpur, Jhansi, Meerut districts of U. P. As the wheat cockles are found in sufficiently large numbers it is presumed that the wheat-gall nematode disease is fairly well established and widely distributed in U. P.

The present specimens closely conform with the description of this species by Thorne, 1949. A short description of this important worm is given below.

Measurements: 8 females: Length = 2.03-3.4 mm.; a = 20-25.3; b = 11-17; c = 38-43; V = 90-91.5%; spear = 9-10.5 μ.

8 males: Length = 1.5-2.08 mm.; a = 21-25; b = 7.7-13; c = 26-29; T = 70-80%.

Female: Body thick, robust, spirally coiled. Head narrowed, set off from body, with two striae. Buccal spear 10 μ long. Dorsal oesophageal gland opening 2 μ posterior to spear base. Excretory pore near middle of irregular, swollen posterior oesophageal bulb. Ovary single, with anterior end reflexed twice on itself; oöcytes arranged about a rachis. Post-uterine branch about one vulvar body diameter long. Tail a little more than two anal body widths long, conoid, tapering to a rounded terminus.

Male: Testis single, with developing spermatocytes arranged in multiple rows about a rachis, reflexed once on itself.

Bursa quite wrapping in the tail. Spicula paired, similar, dagger-shaped, dorsally amalgamated, 32 μ in length. Gubernaculum trough-shaped, 14 μ long.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Basiria* n. g.

Diagnosis: Tylenchinae: Body with conspicuous transverse striae which are interrupted by lateral fields bearing 4 incisures. Lip region elevated, set off by a slight narrowing of the neck contour. Labial frame-work not sclerotized. Amphid apertures large, conspicuous, slit-like, situated posteriorly to base of lateral lips. Deirids and phasmids easily seen. Spear slender, about 12 μ long, divisible into two unequal parts, an anterior tapering tip and a posterior cylindrical shaft bearing three symmetrical, rounded basal knobs. Orifice of dorsal oesophageal gland, as in Helicotylenchus, situated more than half the spear length behind the base of the spear. This is a unique feature among Tylenchinae. Distance from anterior end of body to centre of median oesophageal bulb greater than that from latter to base of oesophagus. Corpus ovate, with distinct valvular apparatus. Basal oesophageal bulb pyriform, set off from intestine. Cardia well developed.

---

* Named after Dr. M. A. Basir under whose guidance this work was done.

Vulva situated in posterior region of body. Ovary single, prodelphic, outstretched; oöcytes arranged in single file. Testis single, outstretched; bursa short, ad-anal; spicules paired, tylenchoid; gubernaculum simple, trough-shaped. Tails of both sexes elongate, filiform.

Type species: Basiria graminophila n. g., n. sp.

Basiria graminophila n. g., n. sp.

(Plate 8, Fig. A-J)

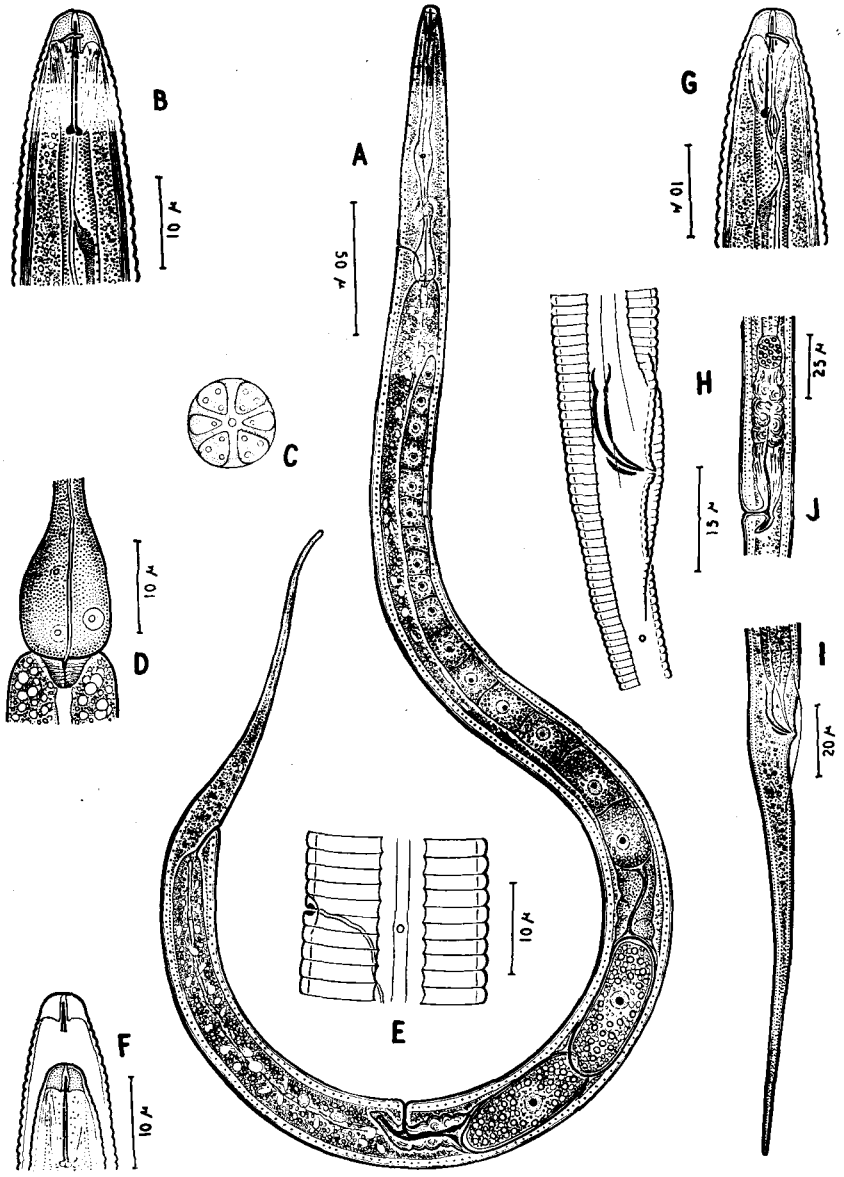
Measurements: 35 females: Length = 0.51-0.82 mm.; a = 30-38; b = 5.4; 7.7; c = 5.5-6.8; V = 61-67%; spear = 11-12 μ; orifice of dorsal oesophageal gland = 9-12 μ from spear base.

20 males: Length = 0.51-0.7 mm.; a = 35-40; b = 5.4-7.4; c = 4.5-6.2; T = 31-48%; spear 10-12 μ; spicules 16-19 μ; gubernaculum = 4-5.5 μ.

Female (Holotype): Length = 0.81 mm.; a = 30.3; b = 7.7; c = 6.7; V = $^{45-}64.3^{-1.6}$%; spear = 12 μ.

Striae 1.6 μ and 1.2 μ apart on mid-body and tail region respectively. Lateral fields two-sevenths of body width, with 4 incisures. Deirids located at level of hemizonid which extends 3 body annules. Lip region elevated, cupolate, 6.5 μ broad at its base and 3.3 μ high, set off from body contour by slight narrowing of neck contour. Cephalic frame-work not sclerotized, hexa-radiate. In an en face view (Pl. 8, Fig. C), six completely amalgamated lips bordering the small, centrally located oral opening can be seen. Lateral lips are smaller than sub-median

PLATE 8



~~Fig. 1.~~ *Basiria graminophila*: A — Female; B — Anterior end of female; C — *En face* view of female; D — Basal oesophageal bulb and cardia; E — Deirid region of female; F — Anterior end of moulting larva; G — Anterior end of male; H — Cuticular pattern of male tail; I — Tail end of male; J — Uterus with spermatheca.

lips which are heart-shaped. Large, slit-like amphid apertures are located behind base of lateral lips.

Buccal spear 12 μ long, with two unequal parts; basal knobs rounded, symmetrical, 1.6 μ across. Inner margins of labial frame-work forming a short guiding tube for spear. Precorpus 4 μ in diameter, with outlet of dorsal oesophageal gland located 9 μ behind spear base. Median oesophageal bulb ovate, 10 μ long by 6.5 μ wide, with a distinct valvular apparatus. Distance from anterior end of body to middle of corpus is in ratio of 5 : 4 to latter to base of oesophagus. Isthmus cylindrical, slightly narrower than precorpus, expanding to form a pyriform basal oesophageal bulb which is completely set off from intestine, enveloped by nerve ring. Excretory pore sclerotized, located ventrally at level of beginning of basal oesophageal bulb and just into the hemizonid area. Cardia large, conoid. Intestine with a well defined lumen throughout; intestinal cells packed with rounded, refractive granules, causing the live eelworms appearing opaque and dark.

Vulva a depressed, transverse slit, occupying two-fifths of body diameter. Vagina short, about one-third body diameter long. Posterior uterine branch about half a vulvar body width. Uterus highly muscular, with two well developed but unsegmented eggs measuring 56 μ by 20 μ. Ovary outstretched anteriorly, its oöcytes in single file. A spherical spermatheca containing sperms present at distal end of uterus. Vulva-anus distance greater than tail length.

Rectum 13 μ long, opening through a conspicuous anus.

Tail filiform, tapering regularly to a smoothly rounded terminus, 9 anal body diameters long, distinctly striated.

Male (Allotype): Length = 0.69 mm.; a = 36.3; b = 6; c = 5.9; T = 40%.

Male essentially similar to female but body striations about 1.3 μ apart; lateral fields expanding on tail as in Fig H; head not striated; spear 11 μ long. Amphidial duct forms a globular pouch packed with hair-like sensillae, at level of spear base (Fig. G). Testis single, outstretched. A small, ad-anal bursa originating slightly anterior to head of spicules and terminating near phasmids; its edges distinctly crenate. Spicula paired, similar, ventrally arcuate and distinctly cephalated, 18.5 μ long, resting on a simple trough-shaped gubernaculum measuring 5 μ long.

Holotype: Female collected on 15th December, 1958; slide no. PN/T/4-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male collected on 20th December, 1958; slide no. PN/T/4-002; other data same as for holotype.

Paratypes: Hundreds of males and females collected around grass and citrus roots; other data same as for holotype.

Type habitat: Collected from soil around roots of grass, Cynodon dactylon Pers.

Type locality: Aligarh (U.P.), India.

Hosts and geographical distribution: Specimens of this species have been collected from soil around pasture and lawn grass roots in various localities in Aligarh, Mathura, Pilibhit

districts of U. P.; also around citrus roots (Citrus limon (L.) Burm. and C. aurantium L.) in Aligarh and Banda districts of the same State. It is presumed that the species is widely distributed in North India.

Discussion: Basiria n. g. is closely allied to Psilenchus de Man, 1921, of the Tylenchinae, from which it is essentially differentiated by the position of the orifice of the dorsal oesophageal gland at three-quarters to one spear length from the spear base. Psilenchus itself contains only a few species and shows considerable morphological diversities, e. g. lip region with or without striae, spear with or without plain or asymmetrical knobs, single or paired ovaries etc. The finding of further species may well lead to a division of the genus.

Basiria is the only genus of the Tylenchinae in which the dorsal oesophageal gland opens some distance behind the spear base. In the Hoplolaiminae, Helicotylenchus Steiner, 1945, is distinguished in a similar way and in the Nacobbinae Rotylenchulus Linford and Oliveira, 1940, has the orifice half-way between the spear base and median bulb.

The slit-like amphid apertures are found in Psilenchus and in Tylenchus Bastian, 1865, as well as in Basiria. The three genera have considerable affinities and may well have been derived from a common ancestral stock.

Telotylenchinae n. sub-fam.

Diagnosis: Tylenchidae: Body elongate, cylindrical, transversely striated. Lateral fields marked by incisures. Head with six, amalgamated lips. Cephalic frame-work hexa-radiate, with little or no sclerotization. Buccal spear well developed, with three basal knobs. Median oesophageal bulb with a valvular apparatus. Isthmus not forming a basal oesophageal bulb as in Tylenchinae but directly opening into intestine. Oesophago-intestinal junction indistinct. Oesophageal glands elongate, lying free in body cavity, extending back over anterior end of intestine. Nucleus of dorsal oesophageal gland located posterior to sub-ventral gland nuclei. Ovary single or paired, outstretched. Vulva transverse. Testis single, outstretched. Tails of both sexes more than one anal body diameter long. Bursa present. Spicula and gubernaculum tylenchoid. Phasmids located on tail.

Type genus: Telotylenchus n. g.

Telotylenchinae n. sub-fam. is closest to Tylenchinae from which it differs in the absence of the basal oesophageal bulb. It can not be justly accommodated in Hoplolaimidae because of the absence of the heavily sclerotized cephalic frame-work characterizing that family and also due to the difference in the structure and the position of the oesophageal glands and in the situation of their nuclei.

Key to the genera of Telotylenchinae

1. Ovaries paired, bursa enveloping entire tail .....
..... Telotylenchus n. g.
Ovary single, bursa not enveloping entire tail ....
..... Pseudhalenchus Tarjan, 1958

Telotylenchus n. g.

Diagnosis: Telotylenchinae: Both sexes similar in appearance. Body elongate, eel-like, bearing distinct transverse striae. Labial frame-work not sclerotized. Buccal spear well developed, elongate, with three basal knobs. Median oesophageal bulb with powerful valvular apparatus. Oesophageal glands elongate, extending back over anterior end of intestine; nucleus of dorsal gland large, located posterior to those of the subventral glands. Oesophago-intestinal junction indistinct; cardia absent. Vulva situated near middle of body. Ovaries paired, outstretched, opposed. Female tail elongate-conoid, with blunt terminus. Male tail pointed, completely enveloped by bursa. Spicula and gubernaculum tylenchoid. Phasmids pore-like, located on tail.

Type species: Telotylenchus indicus n. g., n. sp.

Telotylenchus indicus n. g., n. sp.

(Plate 9, Fig. A-G)

Measurements: 9 females: Length = 0.7-0.88 mm.; a = 35-43; b = 5.8-7.8; c = 13.8-17; V = 52-55.5%; spear = 16-18 μ.

4 males: Length = 0.7-0.84 mm.; a = 40-47; b = 6-7; c = 13-5-15.5; T = 50-63%; spear = 15-16 μ; spicula = 22-24 μ; gubernaculum = 11-12.5 μ.

6 larvae: Length = 0.56-0.66 mm.; a = 31-34; b = 5.4-5.9; c = 12.6-14.7; spear = 14-15 μ.

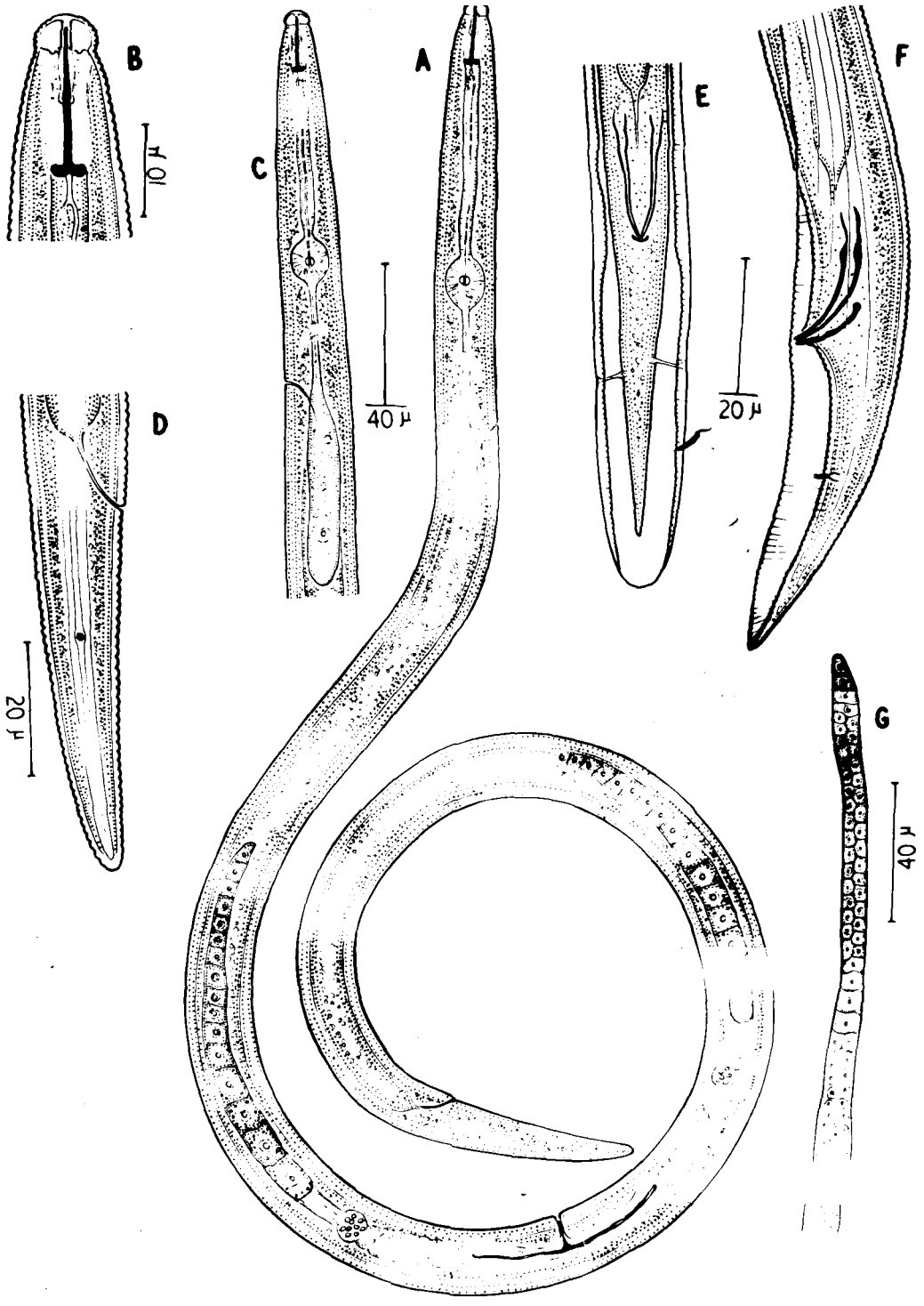
Female (Holotype): Length = 0.84 mm.; a = 42.2; b = 7.3; c = 16; V = $^{22.7-}_{53}{}^{-21.6}$%.

Body elongate and slender, tapering regularly towards either extremities, assuming a slightly ventrally arcuate position when the worm is killed by gradual heat. Striae distinct, 1 μ apart on mid-body. Lateral fields two-sevenths as wide as body, with 4 incisures of which outer ones are crenate. Deirids not observed. Head rounded, 7 μ in diameter, set off button-like from body by a deep constriction and marked by seven striae. Labial frame-work hexaradiate, not sclerotized, with inner margins forming a guiding tube for the spear.

Buccal spear 17 μ long, divisible into two equal parts. Basal knobs of spear strongly developed, 4 μ across, with outer margins slightly directed forward. Orifice of dorsal oesophageal gland 3 μ behind spear base. Median oesophageal bulb slightly ovate, 14 μ long by 11 μ broad, highly muscular, with powerful valvular apparatus in centre. Isthmus elongate, enveloped by nerve ring near its middle, not forming a bulb at its base. Oesophageal glands cylindrical, three body widths long, lying free in body cavity, extending back on left side of

Plate 9. Figures A-G, Telotylenchus indicus. A. Female; B. Head end of female; C. Oesophageal region of male; D. Female tail; E. Male tail, ventral view; F. Male tail, lateral view; G. Testis.

PLATE 9



intestine. All the three glands almost amalgamated although a slight indication of their being separate is seen in some specimens; gland nuclei distinct, that of the dorsal gland larger than and located posteriorly to those of sub-ventral glands. Excretory pore about one body width posterior to level of nerve ring, near the indistinct oesophago-intestinal junction. Hemizonid obscure. Intestinal cells with small, refractive granules; lumen distinct throughout.

Vulva a transverse, depressed slit, 6.5 μ wide. Vagina directed inwards, at right angles to body axis, communicating with a muscular uterine chamber measuring 62 μ long. Two sets of reproductive organs outstretched in opposite directions, lying on right side of intestine. Uteri highly muscular, each containing a spheroidal spermatheca with few sperms at its distal end. Oviducts short. Ovaries outstretched, each with 16 oöcytes arranged in single file.

Rectum short, conspicuous, one anal body diameter long, opening outside through a distinct anus. Tail elongate-conoid, 4 anal body diameters long, regularly tapering to a bluntly rounded, unstriated terminus. Phasmids dot-like, at one-third the distance down the tail.

Male (Allotype): Length = 0.72 mm.; a = 40; b = 6.2; c = 15; T = 50%.

Body essentially similar to that of female. Buccal spear 16 μ long. Oesophageal glands elongate, cylindrical, applied on left side of anterior end of intestine. Testis single, outstretched; spermatocytes arranged as illustrated (Fig. G).

Bursa large, excenate, arising at about one tail length anterior to cloacia, completely enveloping tail. Spicula paired, ventrally arcuate, cephalated, 23 μ in length. Gubernaculum simple, appearing rod-shaped in lateral view, with proximal end slightly bent upwards, 11 M in length, Phasmids anterior to middle of tail, extending into bursa. Tail slightly ventrally arcuate, regularly tapering to a pointed terminus.

Larvae; Body similar to that of female. Cuticle striae rather coarse, 1.4 M apart on mid-body. Buccal spear and oesophagus as described for female. Tail elongate-conoid, tapering to a smoothly rounded terminus.

Holotype; Female collected on 13th January, 1958; slide no. PN/T/5-008; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype; Male; slide no, PN/T/5-009; other data same as for holotype.

Paratypes; 8 females, 3 males, and 6 larwae; other data same as for holotype. 1 female paratype with Dr. J. Basil Goodey, Rothamsted Experimental Station, Harpenden, England,

Type habitat; Collected from soil about roots of grass, Cynodon dactylon Pers.

Type locality; Aligarh (U. P.), India,

Discussion; Tarjan (1953) erected a new genus, Pseudhalenchus, to accommodate species resembling those of the genera Tylenchus and Ditylenchus of the Tylenchinae, but differing from them mainly in the absence of a basal oesophageal bulb. He placed this genus in Tylenchinae Filipjev, 1934.

Telotylenchus n. g. is similar to Pseudhalenchus in many respects especially in the structure of the oesophagus. The inclusion of these two genera in Tylenchinae is not justified because the latter is characterized by the possession of a basal oesophageal bulb. Therefore, a new sub-family, Telotylenchinae, is erected to receive them.

The position of the genus Halenchus Cobb, 1933 is still uncertain. Cobb (1933) and Chitwood (1950) placed it in Tylenchinae while Thorne (1949) regarded it as a member of Nothotylenchinae of the family Neotylenchidae Thorne, 1949. However, Tarjan (1957) emended the diagnosis of Halenchus placir it in Tylenchinae. As regards the structure of the basal portion of the oesophagus Halenchus should also belong to Telotylenchinae but, because the median oesophageal bulb and its valvular apparatus are indistinct in this genus, its inclusion in Telotylenchinae is avoided for the present.

Sub-family Nacobbinae Chitwood and Chitwood, 1950

Diagnosis: Hoplolaimidae: Marked sexual dimorphism present. Females saccate, sedentary; males active, slender. Oesophageal glands extending back over anterior end of intestine. Vulva post-equatorial or sub-terminal. Ovary single or paired. Bursa sub-terminal or terminal.

Type genus: Nacobbus Thorne and Allen, 1944.

Key to genera of Nacobbinae

1. Ovary single ..... Nacobbus Thorne and Allen, 1944
   Ovaries paired ..... Rotylenchulus Linford and Oliveira, 1940

Genus Rotylenchulus Linford and Oliveira, 1940
Syn: Spirotylenchus Lordello & Cesnik, 1958 (?)

Diagnosis: Nacobbinae: Adult female saccate or kidney-shaped, body hangs outside root. Adult male with degenerated spear and oesophagus. Orifice of dorsal oesophageal gland one spear length behind spear base. Oesophageal glands lobe-like, extending back over anterior end of intestine. Gonads paired; ovaries and uteri coiled in adult. Bursa in male sub-terminal.

Type species: Rotylenchulus reniformis Linford and Oliveira, 1940.

The genus Rotylenchulus was erected by Linford and Oliveira in 1940 when they described a new nematode, Rotylenchulus reniformis. Since then, no other species has been added to this genus. The genus Spirotylenchus Lordello and Cesnik, 1958, is possibly a synonym of Rotylenchulus. The females of Spirotylenchus, as described by Lordello and Cesnik (1958), appear to be very similar to the immature females of Rotylenchulus. It is quite possible that Lordello and Cesnik (1958) were dealing with immature females when they described Spirotylenchus.

Rotylenchulus reniformis Linford and Oliveira, 1940

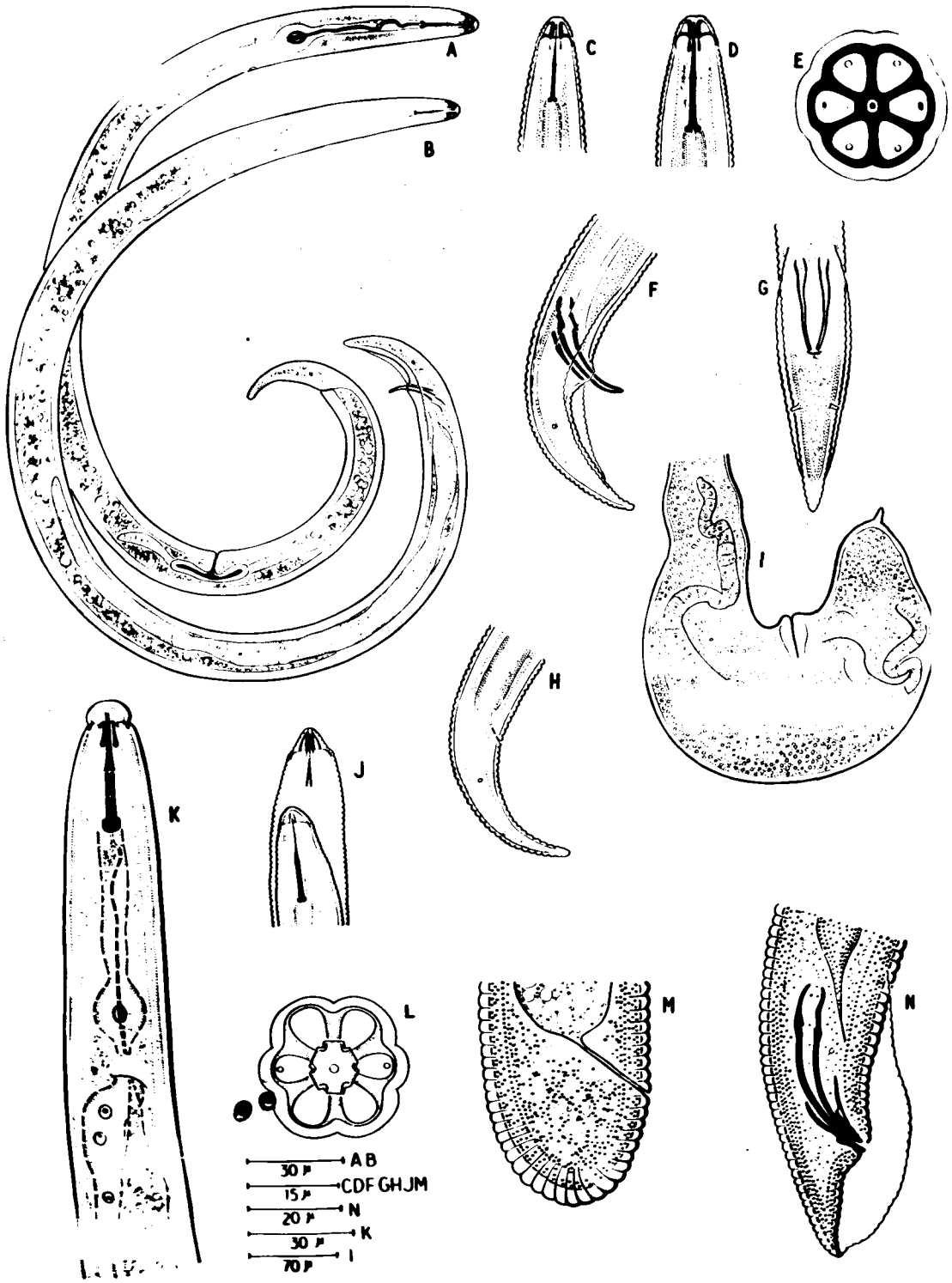
(Plate 10, A-J)

This nematode was originally described by Linford and Oliveira (1940) from Island of Oahu, Hawaii, parasitizing roots of Vigna sinensis Endl. (cowpea). In the same year Linford and Yap listed 65 plant species belonging to 30 different families as serving host for this parasite. Peacock (1956) has listed further host-plants from Gold Coast. The parasite has now been found to be widely distributed in U. P. It is the first time that this species is being reported from ~~India~~ U.P. Almost all the host recorded for this parasite are new records.

The morphological details of the specimens collected by the author are similar to those given by Linford and Oliveira (l. c.). The oesophageal glands in the present specimens are lobe-like and extend back over anterior end of intestine. The

Plate 10. Figures A-J, Rotylenchulus reniformis.
A. Pre-adult female; B. Male; C. Head end of male; D. Head end of female; E. En face view; F. Male tail, lateral view; G. Male tail, ventral view; H. Female tail, lateral view; I. Adult female; J. Anterior end of moulting larva. K-N, Hoplolaimus tylenchiformis. K. Oesophageal region of female; L. En face view; M. Female tail; N. Male tail.

PLATE 10



hemizonid, in premature females, lies one body annule anterior to excretory pore and extends two body annules. Principal body measurements and suitable diagrams of this species based on the study of the present specimens are being given here-under.

Measurements: 12 pre-adult females: Length = 0.386-0.42 mm.; a = 21-29; b = 4.6-5.5; c = 14-17; V = 70-73%; spear = 16.5-19.5 µ.

15 males: Length = 0.4-0.448 mm.; a = 25-30; b = 4.2-5.7; c = 13-20; spear = 12-13 µ; spicules = 18-20 µ; gubernaculum = 8-10 µ.

10 larvae: Length = 0.35-0.385 mm.; a = 22-25; b = 4.1-4.3; c = 12-16.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and localities: Mango, Mangifera indica L.*: Aligarh, Bulandshahr, Meerut, Haldwani (Nainital District), Jhansi and Banda (U. P.); Citrus limon (L.) Burm.*: Aligarh, Badaun and Jhansi; C. reticulata Blanco: Aligarh, Jhansi (U.P.), Yeotmal (Maharashtra State); Carica papaya L.*: Aligarh; Coffea arabica L.: Ossoor (S. India); Grewia asiatica L.*: Aligarh; sunflower, Helianthus annuus L.*: Aligarh. (Mature females were collected from the plants marked with *).

Sub-family Hoplolaiminae Filipjev, ~~1936~~

(for diagnosis vide Andrássy, 1958)

Key to genera of Hoplolaiminae

1. Phasmids normal, pore-like ..... Rotylenchus genus-group.. 2
   Phasmids large, scutellum-like ..Hoplolaimus genus-group.. 4
2. Orifice of dorsal oesophageal gland 1/3 spear length or more behind spear base ..... Helicotylenchus Steiner, 1945
   Orifice of dorsal oesophageal gland less than 1/3 spear length behind spear base 3
3. Lip region marked by transverse and longitudinal striae; gubernaculum bearing lateral titillae ..... Rotylenchus Filipjev, 1936
   Lip region marked by transverse striae only; gubernaculum without titillae .... Gottholdsteineria Andrássy, 1958
4. All three bands of lateral fields transversely striated; spear knobs anteriorly sharp, furcate .... Hoplolaimus Daday, 1905
   Central band of lateral fields smooth, not striated; spear knobs rounded, not furcate ..... Scutellonema Andrássy, 1958

Genus Hoplolaimus Daday, 1905

(diagnosis as given by Andrássy, 1958)

Type species: Hoplolaimus tylenchiformis Daday, 1905.

Key to species of Hoplolaimus

1. Excretory pore located anterior to median oesophageal bulb ..... proporicus Goodey, 1957
   Excretory pore located posterior to oesophageal bulb 2
2. Spermatheca in females absent; males not known..... 3
   Spermatheca in females present; males abundant 4
3. Excretory pore located anterior to hemizonid .....
   ..... seinhorsti Luc, 1958
   Excretory pore located posterior to hemizonid .....
   ..... aberrans Whitehead, 1959
4. Lateral fields distinct; gubernaculum with titillae ..
   ..... tylenchiformis Daday, 1905
   Lateral fields rudimentary; gubernaculum without titillae
   ..... angustalatus Whitehead, 1959

Hoplolaimus tylenchiformis Daday, 1905

Syn: Hoplolaimus coronatus Cobb, 1923

(Plate 10, Fig. K-N)

Daday (1905) established the genus Hoplolaimus by describing a single female specimen which he called Hoplolaimus tylenchiformis from Paraguay. His description was meagre and diagrams were poor. In 1923, Cobb emended the generic diagnosis of Hoplolaimus Daday, 1905. Cobb (1923) described a new species, H. coronatus, which was later synonymized by Andrássy (1958) with

Daday's H. tylenchiformis.

H. tylenchiformis is an almost cosmopolitan species. The author has collected it from various localities in Uttar Pradesh. These specimens closely conform to the description of the species given by Andrássy (1958). Measurements of 10 females and 5 males are given below.

Measurements: 10 females: Length = 1.08-1.22 mm.; a = 29-35; b = 8.8-11; c = 52-63; V = 51-63%; spear = 37-39 μ.

5 males: Length = 1-1.2 mm.; a = 32-35; b = 8.6-9; c = 38-42; spicula = 38-40 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and distribution: Specimens of this species have been collected from the following hosts at Aligarh: Hibiscus esculentus L., S. melongena L., Grewia asiatica L., Citrus limon (L.) Burm., C. sinensis (L.) Osbeck, C. reticulata Blanco, C. aurantium L., Mangifera indica L., Eugenia jambolana Lamk., Psidium guajava L., Tamarindus indica L., Brassica oleracea L. and Aegle marmelos Correa. The author has collected this parasite around roots of citrus trees in 13 districts of this State.

Genus Helicotylenchus Steiner, 1945

Diagnosis: Hoplolaiminae: Lateral fields distinct, not marked by transverse striae. Spear massive, over 20 μ long, with powerful rounded basal knobs. Outlet of dorsal oesophageal gland located 1/3 or more of spear length behind spear base. Females didelphic, with outstretched ovaries. Female tail short, less than 2 anal body diameters long; terminus rounded or with a pointed process; striae following tail contour. Males where known with a non-costate bursa completely enveloping tail. Gubernaculum without titillae. Phasmids small, pore-like, ad-anal or pre-anal in position.

Type species: Helicotylenchus nannus Steiner, 1945.

In 1945, Steiner erected the genus Helicotylenchus and discussed its affinities with Rotylenchus Filipjev, 1934, the chief difference between these two genera being the position of the orifice of dorsal oesophageal gland. Steiner (1945) described H. nannus from the roots of lima beans growing in Maryland and made it the type of the genus. However, Goodey (1951) had not recognized this genus and doubtfully regarded H. nannus as a synonym of Rotylenchus erythrinae (Zimmermann). Recently, Golden (1956) reviewed the genus Helicotylenchus and Rotylenchus and transferred H. multicinctus and R. erythrinae to Helicotylenchus.

Very little is known about Helicotylenchus spp. of India. Das (1960) described Rotylenchus (now Helicotylenchus) multicinctus (Cobb) as a common parasite of banana plants in

Hyderabad (S. India). He also described a new species viz. H. crenatus from roots of Solanum melongena, Beta vulgaris and Solanum lycopersicon collected at Hyderabad. The present author has collected H. erythrinae (Zimmermann) and H. multicinctus (Cobb) in various localities of U. P. These two species are briefly described below.

Helicotylenchus Multicinctus (Cobb, 1893) Golden, 1956

Syn: Tylenchus multicinctus Cobb, 1893

Rotylenchus multicinctus (Cobb, 1893) Filipjev, 1936

Anguillulina multicincta (Cobb, 1893) Goodey, 1940

(nec. Anguillulina multicincta (Cobb, 1893) Goodey, 1932)

(Plate 11, Fig. A-F)

Cobb (1893) described this species as Tylenchus multicinctus from roots of banana plants in Fiji. It was re-described by Goodey (1940) who obtained his specimens from banana roots originating in Apia, Samoa. He also reported finding of a single female specimen from dwarf banana, Musa cavendishii Lamb.; in Guadeloupe, French West Indies. Filipjev (1936) put this species with Rotylenchus. Finally, Golden (1956) transferred it to Helicotylenchus.

The present author has collected this species from banana plants in Punjab as well as U. P. It appears that the species is widely distributed in India. The present specimens closely conform to the descriptions of Goodey (1940) and Cobb (1893). Principal body measurements for the species are given below and suitable illustrations have also been added.

PLATE 11

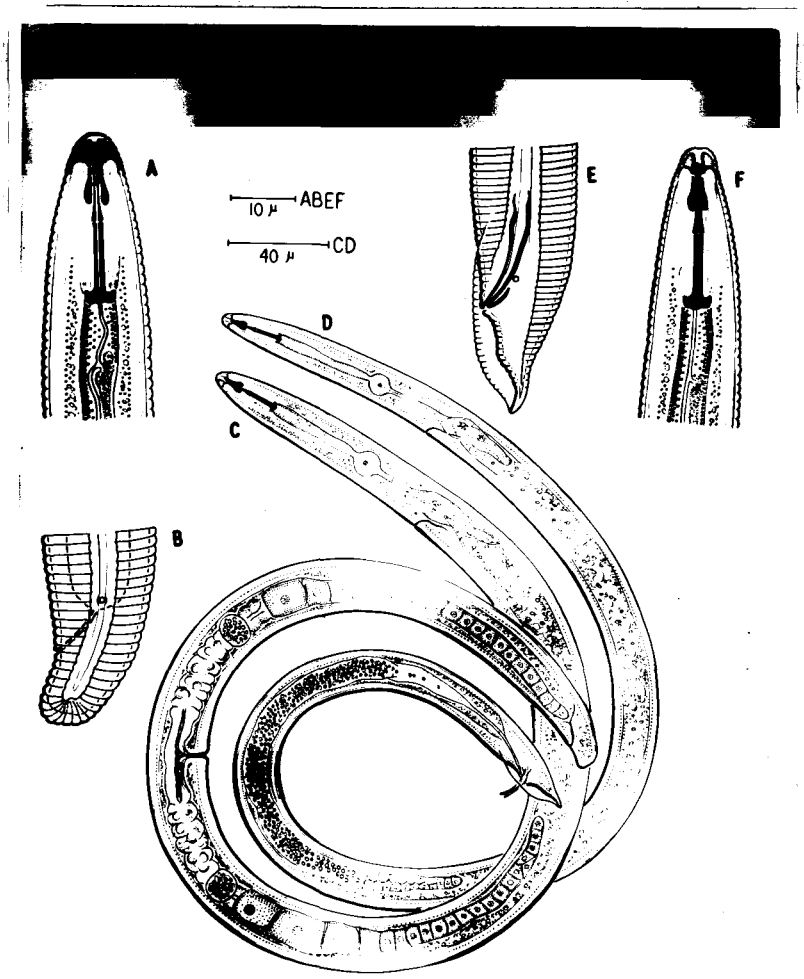


Plate 11. Figures A-F, Helicotylenchus multicinctus. A. Head end of female; B. Female tail; C. Female; D. Male; E. Male tail; F. Anterior end of male.

Measurements: 15 females: Length = 0.52-0.678 mm.; a = 25-30; b = 6-7; c = 44-55; V = 64-68%; spear = 24-25 μ.

12 males: Length = 0.53-0.62 mm.; a = 30-35; b = 6-6.8; c = 30-36; T = 32-50; spicula = 18-20.5 μ; gubernaculum = 5-7 μ; spear = 21-23 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Host and distribution: The author has collected specimens of this species from banana roots, Musa paradisiaca L., in Hathras, Aligarh District (U. P.) and Malerkotla (Punjab State).

Helicotylenchus erythrinae (Zimmermann, 1904) Golden, 1956

Syn: Tylenchus erythrinae Zimmermann, 1904

Tylenchus pseudorobustus Steiner, 1914

Aphelenchus dubius var. peruensis Steiner, 1920

Tylenchus spiralis Cassidy, 1930

Tylenchorhynchus robustus var. erythrinae (Zimmermann, 1904) Bally and Reydon, 1931

Anguillulina multicincta (Cobb, 1893) Goodey, 1932

Tylenchorhynchus multicinctus (Cobb) Schuurmans Stekhoven & Teunissen, 1938

Anguillulina erythrinae (Zimmermann, 1904) Goodey, 1940

Rotylenchus erythrinae (Zimmermann, 1904) Goodey, 1951 (in part)

(Plate 12, A-G)

In 1904, Zimmermann described this species as Tylenchus erythrinae from roots of Erythrina lithosperma Blume from Java.

PLATE 12

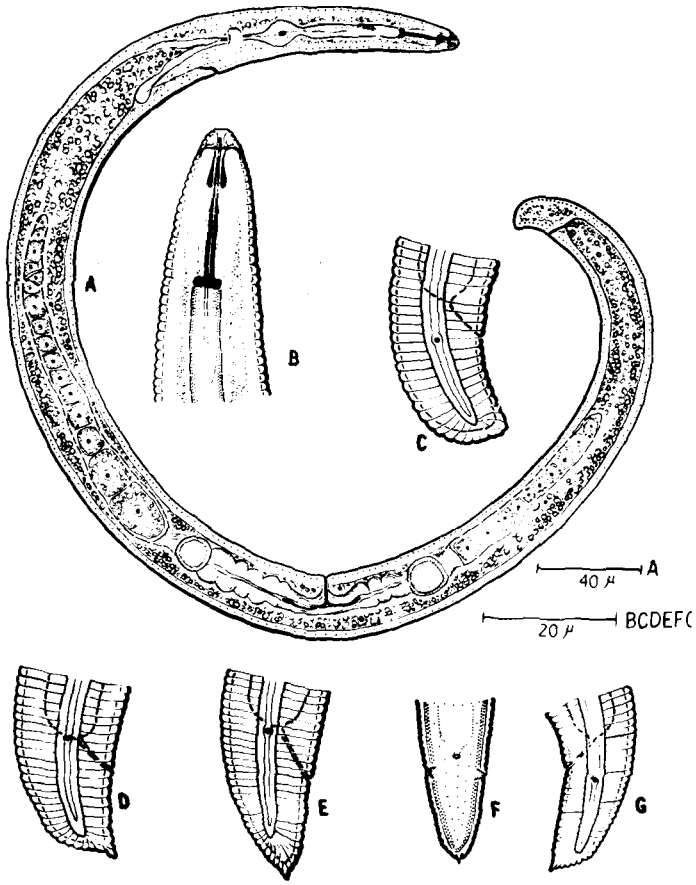


Plate 12. Figures A-G, Helicotylenchus erythrinae. A. Female; B. Anterior end of female; C. Female tail; D-G. Variations in the female tail and location of the phasmids.

The species appears to be cosmopolitan. A study on the present specimens indicates that the tail terminus and the position of the phasmids are variable in this species. These closely coform to the original description of the species. Measurements given by Zimmermann are as follows. Some of these data have been calculated from the original measurements. Length = 0.56-0.7 mm.; a = 26.3; b = ?; c = 26; V = 60-61%.

A short description of the species is given below.

Female:

Measurements: Length = 0.44-0.63 mm.; a = 22.7-32; b = 5.4-6.3; c = 32.2-47; V = $^{22-32}$-61-65-$^{17-22}$%; spear = 21-23 µ.

Body spirally coiled. Striae 1.3 µ apart. Lateral fields with 4 incisures, one-fourth as wide as body. Head bearing 5 annules, cupolate. Spear strong, 21-23 µ long; basal knobs rounded. Orifice of dorsal oesophageal gland 10 µ behind spear base. Excretory pore slightly anterior to level of oesophago-intestinal junction. Hemizonid 2 body annules long, located just anterior to excretory pore. Ovaries paired, outstretched, with oöcytes in single row. Empty spermatheca present in each uterus. Phasmids dot-like, usually situated at latitude of anus; its position variable (Plate 12, Fig. E-G). Tail ventrally arcuate, bearing greater curvature on its dorsal side. Caudal terminus usually rounded, sometimes with a terminal mucronate process. Striae following tail contour. Egg 71 µ long by 21 µ broad.

Male: Not found.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Host and distribution: Specimens of this species have been collected around roots of Cynodon dactylon Pers. in some 10 districts of U. P.

Sub-family Pratylenchinae Thorne, 1949

Diagnosis: Hoplolaimidae: Lip region low, flattened, except in Hoplotylus where it is elevated. Phasmids usually located well behind latitude of anus. Spear strongly developed, with well developed rounded basal knobs (basal knobs anteriorly sharp in Hoplotylus). Free oesophageal glands extending back over anterior end of intestine, variable in form and position. Ovary single or paired. Tails in both sexes elongate, usually more than one-and-a-half times anal body diameter long. Bursa present. Female active, slender.

Type genus: Pratylenchus Filipjev, 1934.

Key to genera of Pratylenchinae

1. Ovary single 2
   Ovaries paired 3
2. Basal knobs of spear smooth, lip region low, flattened ..... Pratylenchus Filipjev, 1934
   Basal knobs of spear anteriorly sharp, lip region elevated ..... Hoplotylus s'Jacob, 1959
3. Oesophageal glands taking long overlap with the anterior end of intestine ..... Radopholus Thorne, 1949
   Oesophageal glands taking short, oblique overlap .... Pratylenchoides Winslow, 1958

Genus Hoplotylus s'Jacob, 1959

Diagnosis: Pratylenchinae: Head elevated, slightly set off from body. Spear robust, with three oval basal knobs bearing anteriorly sharp margins. Oesophageal gland elongated, lobe-like, extending back over dorsal side of intestine. Ovary single, outstretched. Post-uterine sac present. Phasmids pore-like, near anus. Tail more than one-and-a-half anal body diameters long. Only females known.

Type species: Hoplotylus femina s'Jacob, 1959.

Key to species of Hoplotylus

1. Tail over three anal body diameters long, attenuated; phasmids ad-anal ..... tenuicaudatus n. sp.
   Tail less than three anal body diameters long, conoid; phasmids slightly post-anal .... femina s'Jacob, 1959

s'Jacob (1959) erected a new genus, Hoplotylus, to accommodate a new nematode species which he called Hoplotylus femina. He placed this genus in Pratylenchinae. However, the position of this genus is still uncertain. It occupies a position intermediate between Hoplolaiminae and Pratylenchinae.

Only one species of Hoplotylus is known. The other species, H. tenuicaudatus n. sp., is being described below.

Hoplotylus tenuicaudatus n. sp.

(Plate 4, Fig. F-G)

Female (Holotype): Length = 0.655 mm.; a = 30; b = 7.4; c = 15.2; V = 27-36.6%.

Body cylindrical, tapering on either extremities, assuming a straight position when the animal is killed by gradual heat. Transverse striae fine, 1 μ apart on mid-body, coarser on tail. Lateral fields with 4 incisures. Head cupolate, with 5 transverse striae, slightly set off from body contour. Cephalic frame-work strongly sclerotized; its outer margins extending 3 body annules.

Buccal spear robust, 23 μ long, with 3 oval, compact basal knobs measuring 4.5 μ across and as much high. Orifice of dorsal oesophageal gland 5 μ behind spear base. Corpus rounded, with a powerful valvular apparatus in centre. Oesophageal glands lying on dorsal side of anterior end of intestine. Excretory pore 107 μ from anterior end of body. Intestine with fewer granules.

Vulva a depressed, transverse slit, about half the vulvar body width long. Posterior uterine branch less than body width at vulva. Uterus with a distal swelling, without sperms. Ovary single, prodelphic; oöcytes in one row.

Rectum less than one anal body width. Anus distinct, located at about half-way the distance from vulva to terminus. Phasmids pore-like, adanal in position. Tail attenuated, tapering to a finely rounded terminus, slightly more than three anal body diameters in length.

Male: Not found.

Holotype: Female collected on 17th June, 1959; slide no. PN/P/1-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Type host: Collected from soil around roots of Citrus limon (L.) Burm.

Type locality: Bhowali (elevation 5,500 feet), Nainital District (U. P.), India.

Diagnosis and relationship: Hoplotylus with the above measurements and general description. It is distinctive because of a slender body, 23 μ long buccal spear, tail being attenuated and measuring three anal body diameters long and adanal position of the phasmids. It differs from H. femina s'Jacob, 1959, the only known species of the genus, in having adanal phasmids (slightly post-anal in femina) and an attenuated tail measuring a little over three anal body diameters long (tail irregularly conoid, less than three anal body diameters long in femina).

Genus Pratylenchus Filipjev, 1934

Diagnosis: Pratylenchinae: No marked sexual dimorphism. Lip region low, flattened, annulated. Spear well developed, less than two-and-a-half times the width of head. Oesophageal glands contained in a single lobe, variable in size and position. Ovary single, outstretched anteriorly. Post-uterine sac present. Phasmids located one-third of the tail length

or more behind latitude of anus. Male tail tapering, completely enveloped by bursa.

Type species: Pratylenchus pratensis (de Man, 1880) Filipjev, 1936.

Key to species of Pratylenchus

1. Lateral fields with 6 incisures .....
..... hexincisus Taylor and Jenkins, 1957
Lateral fields with less than 6 incisures 2
2. Tail terminus asymmetrical 3
Tail terminus rounded, symmetrical 7
3. Tail terminus truncated, set off by a constriction 4
Tail terminus notched 5
4. Female tail less than two anal body diameters long .....
..... brevicercus Das, 1960
Female tail more than two anal body diameters long .....
..... indicus Das, 1960
5. 3 annules on lip region ... convallariae Seinhorst, 1959
2 annules on lip region 6
6. Spear more than 18 μ long; vulva at 82.3-85.9 per cent
..... steineri Lordello et al., 1954
Spear less than 18 μ long; vulva at about 80% .....
..... musicola (Cobb, 1919)
7. 2 annules on lip region 8
3-4 annules on lip region 12

8. Lateral margins of lip angular .. brachyurus (Godfrey, 1929)
   Lateral margins of lips rounded 9
9. Spermatheca present; males abundant 10
   Spermatheca absent; males rare or absent 11
10. a = 25-35; spear = 15-18 μ ... coffeae (Zimmermann, 1898)
    a = 18-25; spear=14-15 μ ..... grandis n. sp.
11. Vulva at 75-80 per cent ..... scribneri Steiner, 1943
    Vulva at 80-88 per cent ..... minyus Sher and Allen, 1953
12. Tail terminus striated 13
    Tail terminus not striated 14
13. Tail terminus broadly rounded .. pratensis (de Man, 1880)
    Tail terminus pointed ..... helophilus Seinhorst, 1959
14. Outer margins of cephalic frame-work prominent, extending posteriorly about two body annules 15
    Outer margins of cephalic frame-work normal 17
15. Spermatheca present; males abundant ..... subpenetrans Taylor and Jenkins, 1957
    Spermatheca absent; males rare 16
16. a = 26-36; body length = 0.45-0.77 mm. ... thornei Sher and Allen, 1953
    a = 20.4-25.8; body length = 0.38-0.47 mm.....
    ..... delattrei Luc,. 1958
17. Vulva at 68-76 per cent 18
    Vulva at 78-84 per cent 19
18. 3 annules on lip region; males absent ... zeae Graham, 1951
    4 annules on lip region; males numerous.. Goodeyi Sher and Allen, 1953

Other species:

P. neglectus (Rensch, 1924) Loof, 1957

P. tumidiceps Merzheyevakaya, 1951

P. pratensis var. bicaudatus Meyl, 1954

P. coffeae brasiliensis Lordello, 1956

Das (1960) described three species of the genus Pratylenchus from Hyderabad (South India) including two new species viz. P. brevicercus and P. indicus. The author has collected five species of this genus at Aligarh (U. P.). Of these one is new to Science. The other four include three species which are being reported for the first time from India. It is proposed to regard P. musicola (Cobb, 1919) Filipjev, 1936, which was doubtfully reduced to a synonym of P. coffeae (Zimmermann) by Sher and Allen (1953), a valid species.

Pratylenchus pratensis (de Man, 1880) Filipjev, 1936

Syn: Tylenchus pratensis de Man, 1880

Tylenchus gulosus Kühn, 1894

Anguillulina pratensis Goffart, 1929, in part

Anguillulina pratensis (de Man, 1880) Goodey, 1932

(Plate 14, Fig. E-G)

Recently, Das (1960) reported this parasite from potato, salad and brinjal occurring in Hyderabad (S. India). The author collected seven female specimens of this species from roots of

maize, Zea mays L., at Aligarh. These specimens closely fit to the description of the species given by Thorne, 1949, and Sher and Allen, 1953. Principal body measurements and suitable diagrams of these are being given here.

Measurements: 7 females: Length = 0.44-0.6 mm.; a = 20-24; b = 6.8-8.5; c = 20-24; V = 77-79%; spear = 16-18 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis: P. pratensis is distinguished by the three annul on the lip region, a robust spear with powerful basal knobs, a rounded tail terminus bearing striations around it, and the absence of a spermatheca.

Pratylenchus grandis n. sp.

(Plate 13, Fig. A-D)

Measurements: 10 females: Length = 0.46-0.68 mm.; a = 18-25; b = 6.5-8.8; c = 17-21.3; V = 70-77.8%; spear = 14-15 μ.

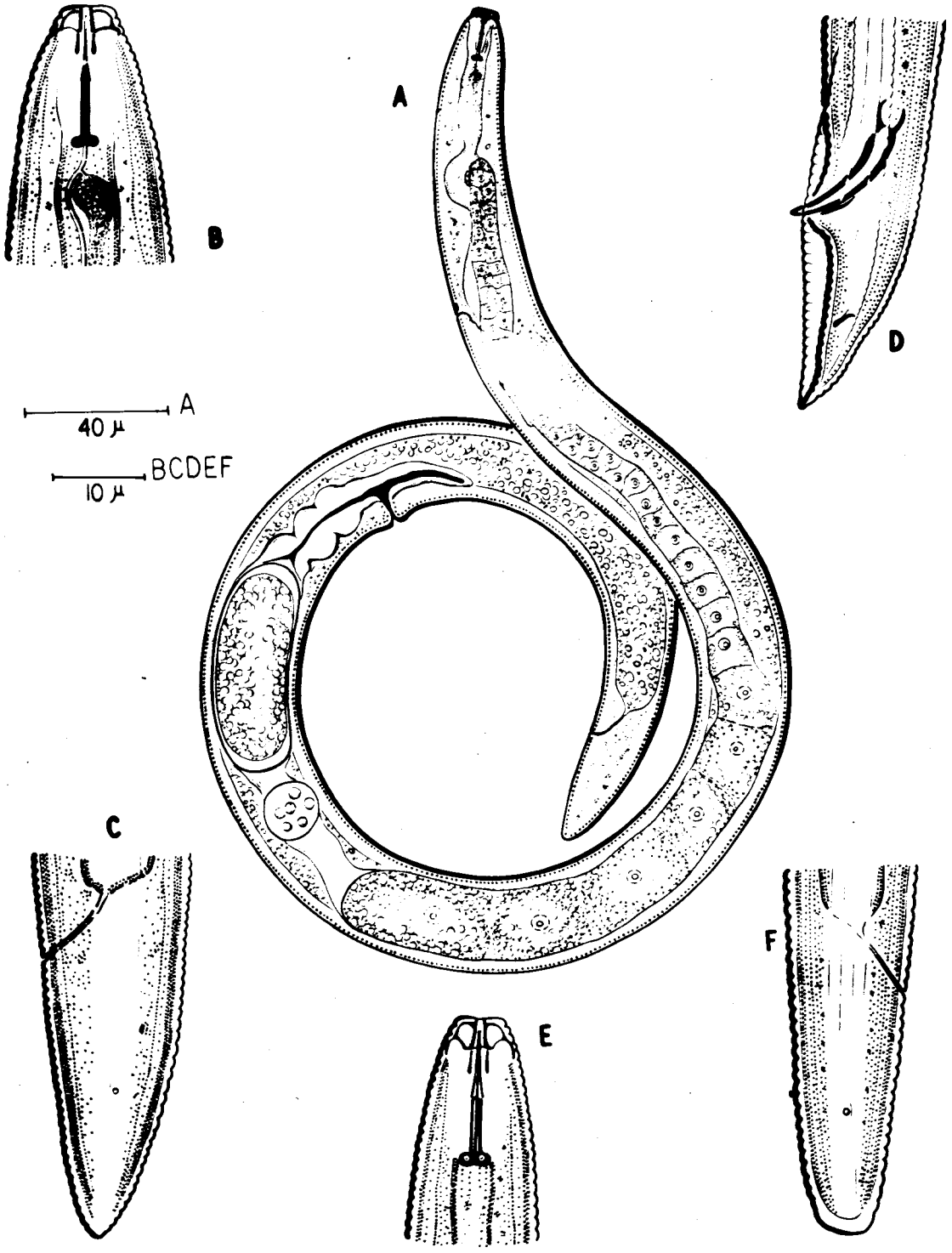
7 males: Length = 0.42-0.5 mm.; a = 25-30; b = 6.2-8; c = 19-23; T = 46-60%; spear=14-14.5 μ; spicula = 17-19 μ.

Female (Holotype): Length = 0.67 mm.; a = 24.8; b = 8.5; c = 21; V = $^{69-}75.6^{-3.8}$%.

Body cylindrical, tapering regularly towards either extremities. Cuticle striae distinct, 1 μ apart on mid-body.

Plate 13. Figures A-D, Pratylenchus grandis. A. Female; B. Head end of female; C. Female tail; D. Male tail. E-F, P. thornei. E. Head end of female; F. Female tail.

PLATE 13



Lateral fields marked by 4 incisures. Phasmids situated on middle of tail. Lip region marked by only one striation forming two annules at that region. Outer margins of cephalic frame-work extending back one body annule. Spear guiding apparatus extending posteriorly from basal plate three body annules. Buccal spear of medium strength, 14.5 μ long. Basal knobs of spear 3 μ across. Dorsal oesophageal gland opening into oesophagus 3 μ behind spear base. Median oesophageal bulb well developed, about three-fourths as wide as corresponding body diameter. Excretory pore slightly behind level of oesophago-intestinal junction. Hemizonid extending two body annules, located just anterior to excretory pore.

Vulva a transverse slit, with raised lips. Vagina extending one-third into body. Post-uterine sac short, about one vulvar body width long. Spermatheca with sperms present at distal end of uterus. Ovary prodelphic, outstretched; oöcytes in single file except for a few near cap-cell. Ovary extending up to oesophagus. Uterine egg 60 μ long by 22 μ broad. Tail regularly tapering to a conoid, rounded terminus which is not striated.

Male (Allotype): Length = 0.45 mm.; a = 25; b = 6.2; c = 19; T = 50%.

Lip region rounded, with two annules. Spear 14 μ long; basal knobs 2.5 μ across by 1.4 μ high. Orifice of dorsal oesophageal gland 3.3 μ behind spear base. Testis single, outstretched. Bursa springing from a level one spicula length anterior to cloaca, completely enveloping tail; its outer margins distinctly crenate. Spicula 18 μ in length; ventral

sides of each prong near cephalic constriction enlarged appearing amalgamated with each other. Gubernaculum simple, trough-shaped, 5 μ long. Phasmids located on middle of tail, slightly extending into bursa.

Holotype: Female collected on 17th December, 1957; slide no. PN/P/2-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/P/2-002; other data same as for holotype.

Paratypes: 9 females and 6 males; other data same as for holotype.

Type host: Collected from roots of Citrus limon (L.) Burm.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Pratylenchus with the above measurements and general description. It is distinctive because of rounded lip region with only two annules; a short buccal spear measuring 14-15.5 μ long; vulva located at 70-77.8 per cent of body from anterior end; presence of a spermatheca; characteristic shape of the spicula; a tapering, conoid tail, with a conoid-rounded, unstriated terminus and abundance of males.

P. grandis n. sp. is closest to P. coffeae (Zimmermann, 1898) Filipjev and Stekhoven, 1941, and P. scribneri Steiner, 1943. From the former it differs in having a shorter and more robust body (a = 25-35 in coffeae), a shorter and weaker spear, more anteriorly located vulva and ovary extending up to oesophageal region; from the latter it can be distinguished by having a weaker and shorter buccal spear (spear=15-17 μ long in scribneri), ovary extending up to oesophageal region, presence

of a spermatheca and abundance of males.

Pratylenchus thornei Sher and Allen, 1953

(Plate 13, Fig. E-F)

A single female specimen, here identified as Pratylenchus thornei, was recovered from soil sample taken around grass roots at Aligarh (U. P.). The specimen closely conforms to the description of P. thornei as given by Sher and Allen, 1953. It is interesting to note that, as far as the author is aware, this species has not so far been reported from Asia. A short description of the worm is given below.

Female: Length = 0.64 mm.; a = 26.4; b = 8.5; c = 22.6; V = $^{37-}_{76}{}^{-3.7}$%.

Striae 1 μ apart. Lateral fields with four incisures, outer ones of which appearing crenate. Lip region rounded, with 3 annules. Outer margins of labial frame-work prominent, extending into body 2 body annules and into lip region 1 annule. Spear strong, 16 μ long; basal knobs robust, 4 μ across. Orifice of dorsal oesophageal gland 3 μ behind spear base. Hemizonid 2 body annules long, 1 body annule anterior to excretory pore, just near oesophago-intestinal junction. Ovary with 27 oöcytes arranged in single file. Spermatheca or sperms not seen. Post-uterine branch a little more than one vulvar body width long. Phasmids slightly posterior to middle of tail. Latter tapering to a broadly rounded, unstriated terminus.

Specimen collected on 5th November, 1955; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis and relationship: This species is distinctive because of its well developed outer margins of cephalic framework; 3 annules on head; position of vulva and broadly rounded, unstriated caudal terminus.

P. thornei is related to P. subpenetrans Taylor and Jenkins, 1957, and P. delattrei Luc, 1958. From the former it can be differentiated by its longer body, a larger spear, more anteriorly placed vulva, absence of a spermatheca and a bluntly rounded tail terminus; and from the latter it differs in having a larger size of body (0.386-0.470 mm. long in delattrei) and a broadly rounded caudal terminus.

Pratylenchus musicola (Cobb, 1919) Filipjev, 1936

(Plate 14, A-D)

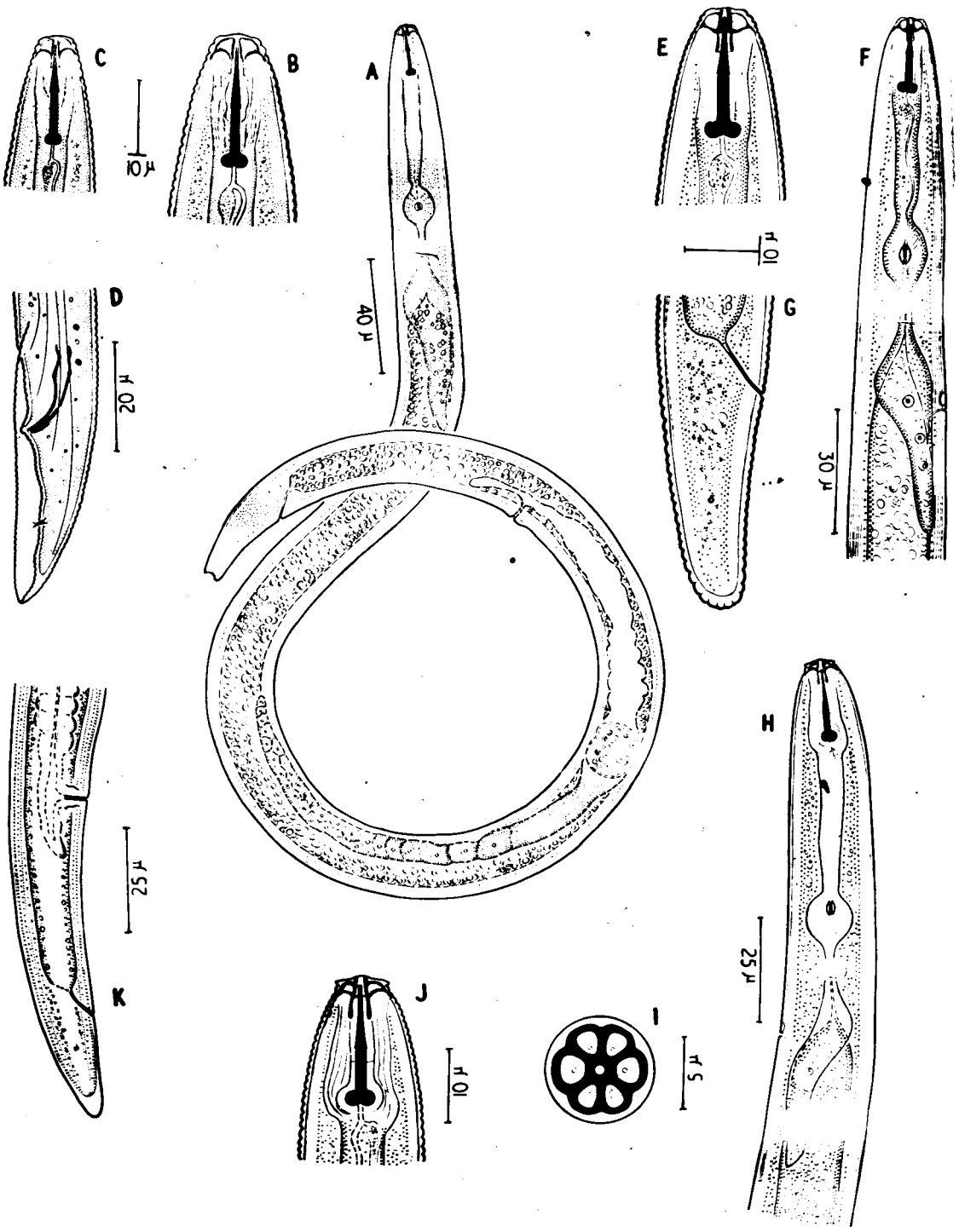
Syn: Tylenchus musicola Cobb, 1919

Tylenchus mahogani Cobb, 1920 (?)

P. musicola (Cobb) was originally described by Cobb in 1919 as Tylenchus musicola from roots of 'Bluggoe' banana originating in Granada, West Indies. Sher and Allen (1953) compared specimens of this species obtained from abaca roots growing in Costa Rica and type material of P. coffeae (Zimmermann, 1898) and reduced the former to a synonym of the latter species.

Taylor and Loegering (1953) called the species attacking

PLATE 14



abacá, Musa textilis Neé in Costa Rica P. musicola (Cobb). They have sketched a female (page 11, Fig. 3, A-C) showing a deep indentation of the tail terminus similar to that described by Cobb (1919). On the head there are two annules and the vulva is at 80 per cent.

The present author has very carefully studied both preserved as well as living specimens of the species, here identified as P. musicola (Cobb), attacking citrus and banana at Aligarh. The caudal terminus in all the female specimens is characteristically notched. This condition is not found in P. coffeae (Zimmermann). This is supported by the description and illustration of female of P. coffeae by Sher and Allen (1953) and Zimmermann (1898). Hence it may be concluded that P. musicola is a valid species.

The author sent some of the present specimens to Dr. W. J. Seinhorst who has very kindly compared them with P. coffeae. According to Seinhorst P. musicola should be regarded a valid species (Personal communications).

A short description of P. musicola, based on the study of the present specimens, follows.

Measurements: 20 females: Length = 0.48-0.7 mm.; a = 23-29.7; b = 5.1-7.2; c = 19-23.4; V = $^{39-78-}_{79-82}$ $^{-3.2-4.8}$%; spear = 15.5-17.5 µ.

10 males: Length = 0.48-0.65 mm.; a = 24-32; b = 6-7; c = 15-22; T = 46-57%; spear = 13.5-15 µ; spicula = 16.5-19 µ.

Female: Transverse striae 1.4 µ apart on mid-body. Lateral fields with 4 incisures, three-sevenths of body diameter. Lip region

rounded, with two annules. Spear 16.5 μ long, with rounded basal knobs. Orifice of dorsal oesophageal gland 2.8 μ behind spear base. Excretory pore just anterior to hemizonid which is three body annules long. Ovary single, outstretched. Spermatheca present. Post-uterine sac equal to body width at vulva. Phasmids slightly posterior to middle of tail. Latter tapering to a broad, irregular, indentated terminus.

Male: Spear weaker than that of female. Testis single, outstretched. Spicula paired, cephalated, 16.5-19 μ in length. Gubernaculum linear, saucer-shaped, 3.5 μ long. Phasmids on middle of tail, extending into bursa.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Present hosts and distribution: Specimens of this species have been collected from roots of Citrus limon (L.) Burm., C. sinensis (L.) Osbeck and C. reticulata Blanco in Aligarh District (U. P.); C. limon in Meerut, Agra and Bulandshahr districts (U. P.); Musa paradisiaca L. at Aligarh and Agra (U. P.).

Diagnosis and relationship: It is distinctive because of only two annules on lip region, presence of a spermatheca, a short post-uterine sac, ovary extending up to oesophageal region, an irregular caudal terminus and abundance of males.

P. musicola (Cobb) resembles closely with P. coffeae (Zimmermann, 1898) Filipjev and Stekhoven, 1941, P. steineri Lordello et al 1954, and P. convallariae Seinhorst, 1959. From the first of these it is distinguished by having a more robust body, ovary extending up to oesophageal region and irregular caudal terminus. From P. steineri it can be differentiated by having a shorter buccal spear and more anteriorly located vulva (V = 82.3-85.9%

in steineri). It differs from P. convallariae in having two annules on head (three annules on head in convallariae) and unstriated caudal terminus.

Pratylenchus brachyurus (Godfrey, 1929) Filipjev and Stekhoven, 1941

Syn: Tylenchus brachyurus Godfrey, 1929
Anguillulina pratensis Goodey, 1932 in part
Pratylenchus pratensis Filipjev, 1934 in part
Pratylenchus leiocephalus Steiner, 1949

(Plate 14, Fig. H-K)

Pratylenchus brachyurus has been found to attack guava trees, Psidium guajava L., at Aligarh. This is the first record of the parasite from India.

Measurements: 10 females: Length = 0.46-0.55 mm.; a = 22-27; b = 6.4-6.9; c = 17-23; V = 83-87%.

Female: Body striae 1.3 µ apart. Lateral fields with 4 incisures. Lip region angular, marked by a single stria. Inner margins of cephalic frame-work extending back from basal plate 5 body annules; outer margins normal, extending one body annule posteriorly. Orifice of dorsal oesophageal gland 2 µ from spear base. Spear 17 µ long; basal knobs 4 µ across by 2 µ high. Hemizonid 3 body annules long, located just anterior to excretory pore. Post-uterine sac almost equal to body width at vulva. Spermatheca not seen.

Phasmids located slightly anterior to middle of tail. Latter conoid, regularly tapering to a large, rounded terminus. Faint striations around terminus of tail seen in some of the specimens.

Male: Not found.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis: This species is distinguished by having an angular head bearing only two annules, posteriorly located vulva and ovary consisting of only one row of oöcytes and not extending to oesophageal region. The above description closely conforms with that given by Sher and Allen (1953) for P. brachyurus (Godfrey).

Genus Radopholus Thorne, 1949

Diagnosis: Pratylenchinae: Head of female as in Pratylenchus, low and flattened. Stylet of female about twice or more the width of lip region, with strong rounded basal knobs. Oesophageal glands taking a long overlap over the anterior end of intestine. Phasmids in both sexes prominent, located well back of the tails. Ovaries paired, outstretched in opposite directions. Bursa enveloping about four-fifths, or entire, of tail. Tails of both sexes elongate-conoid to the rounded or irregular shaped terminus. Marked sexual dimorphism in certain cases.

Type species: Radopholus similis (Cobb, 1893) Thorne, 1949

Key to species of Radopholus

1. Males with degenerated oesophagus 2
   Males with normal oesophagus 4
2. Lateral fields with 4 incisures..... 3
   Lateral fields with 4-7 incisures .. *inaequalis* Sauer, 1958
3. Bursa enveloping entire tail .. *neosimilis* Sauer, 1958
   Bursa not enveloping entire tail .... *similis* (Cobb, 1893)
4. Spear more than 30 μ long ..... *lavabri* Luc, 1957
   Spear less than 30 μ long 5
5. Caudal alae extending past phasmids 6
   Caudal alae not extending past phasmids ..... *gracilis* (de Man, 1880)
6. Tail ending in a flagellum-like process ..... *gigas* Andrássy, 1954
   Tail terminus bearing a pointed spine ..... *mucronatus* Das, 1960

In 1902, von Breda de Haan described a new nematode species, *Tylenchus oryzae*, from diseased rice roots originating in Dutch East Indies. A detailed morphology of this nematode was published by Goodey in 1936. In 1949, Thorne erected a new genus, *Radopholus*, and accommodated this species in it. Later, in 1955, Hirschmann made *Radopholus oryzae* (von Breda de Haan) a synonym of *Radopholus gracilis* (de Man, 1880) Hirschmann, 1955.

Radopholus gracilis is a widely distributed species. It is known both from the Old as well as New World. The parasite is being reported for the first time from India. However, Das (1960) described yet another species from paddy roots which he named Radopholus mucronatus. This species is essentially similar to R. gracilis differing only in the extent of the caudal alae.

The present specimens closely conform to the description of the species given by Hirschmann (1955). However, a short description of this parasite is also given below.

Radopholus gracilis (de Man, 1880) Hirschmann, 1955

Syn: Tylenchus gracilis de Man, 1880

Chitinotylenchus gracilis (de Man, 1880) Micoletzky, 1921

Tylenchorhynchus gracilis (de Man, 1880) Micoletzky, 1925

Anguillulina gracilis (de Man, 1880) Goodey, 1932

Tylenchorhynchus gracilis (de Man, 1880) Filipjev, 1936

Tylenchus oryzae von Breda de Haan, 1902

Anguillulina oryzae (von Breda de Haan, 1902) Goodey, 1932

Rotylenchus oryzae (von Breda de Haan, 1902) Filipjev and Schuurmans Stekhoven, 1941

Radopholus oryzae (von Breda de Haan, 1902) Thorne, 1949

Tylenchus apapillatus Imamura, 1931

Tylenchorhynchus behningi Micoletzky, 1923

(Plate 15, Fig. A-G)

Measurements: 20 females: Length = 1.26-2.10 mm.; a = 48-58; b = 13-15.5; c = 16-20; V = 51-59%.

10 males: Length = 1.15-1.78 mm.; a = 50-61; b = 12.5-16;

PLATE 15

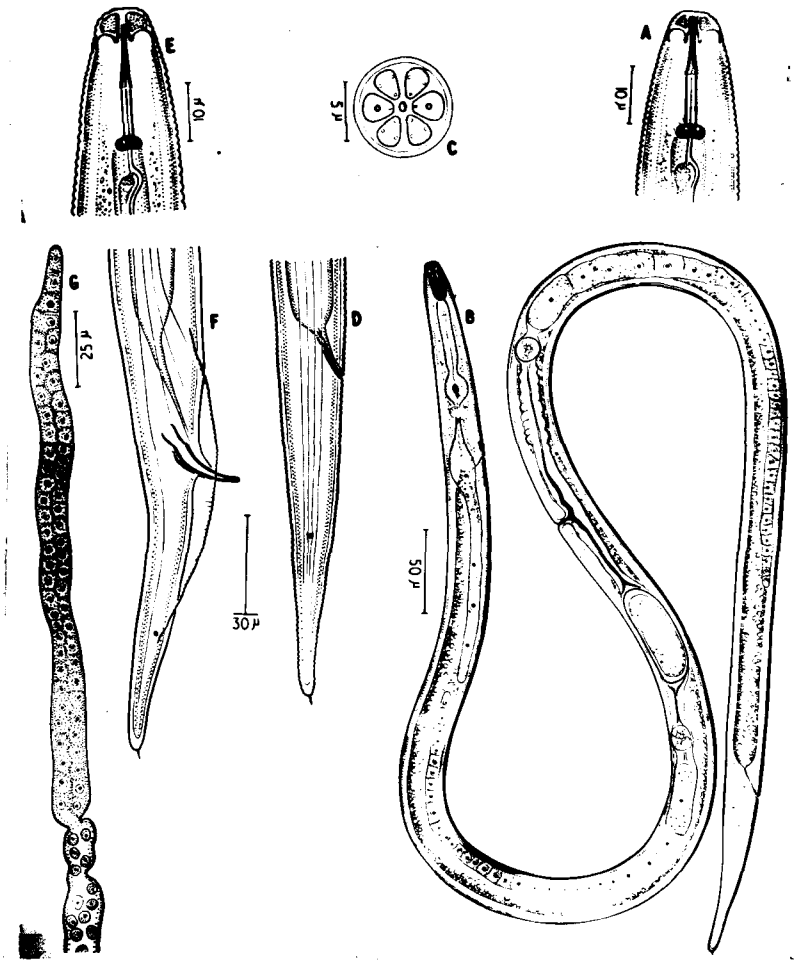


Plate 15. Figures A-G, Radopholus gracilis. A. Head end of female; B. Female; C. En face view; D. Female tail; E. Head end of male; F. Male tail; G. Testis.

c = 15-20; T = 51-70%.

Female: Striae 1.5 μ apart. Lateral fields with 4 incisures. Spear 22.5 μ long. Hemizonid 5 body annules long, 4 body annules anterior to excretory pore. Ovaries paired, outstretched. Spermathecae present. Egg 60 μ long by 22 μ broad. Tail elongate, regularly tapering to a rounded terminus bearing a small mucronate spine.

Male: Spear 22 μ long. Spicula 29 μ in length. Gubernaculum 11 μ long. Bursa sub-caudal, crenate, ending near phasmids. Tail about five anal body diameters long, with a mucro at its tip.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected from roots of paddy and grass, Cyperus rotundus L. at Aligarh, Pilibhit, Badaun, Kanpur, Banda, Meerut (U.P.); grass roots at Jabalpur (M. P.). The parasite appears to be well distributed in rice soils of Aligarh, Meerut and Pilibhit districts of U. P.

Diagnosis and relationship: The species is distinctive because of the size of body and spear, female tail bearing a spine, caudal alae in male terminating near phasmids and male having normal oesophagus and spear.

R. gracilis is related to R. mucronatus Das, 1960, differing essentially in having caudal alae of male not extending past phasmids. From R. lavabri Luc, 1957, it is distinguished by having a flattened head and shorter spear (42-45.5 μ long in lavabri).

Family Heteroderidae Thorne, 1949

Diagnosis: Tylenchoidea: Females lemon-shaped or pyriform. Male active, developing by metamorphosis within the swollen cyst of larval cuticle. Male tail short, rounded. Bursa absent. Obligate plant-parasites.

Type sub-family: Heteroderinae Filipjev, 1934.

Sub-family Heteroderinae Filipjev, 1934

Diagnosis: Heteroderidae: Oesophageal glands overlapping anterior end of intestine. Dorsal oesophageal gland opening just behind spear base. Vulva terminal; ovaries paired. Anus sub-terminal. Bursa in male absent. Male tail short, rounded. Female saccate or cyst-forming.

Type genus: Heterodera Schmidt, 1871.

Key to genera of Heteroderinae

1. Eggs retained in body which forms a protective cyst; anus moderately removed from vulva 2
   Eggs not retained in body; anus at edge of posterior lip of vulva ..... Meloidogyne Goeldi, 1887
2. Body surface with transverse markings which form a finger-print-like pattern in perineal region .....
   .....Meloidodera Chitwood et al., 1956.
   Body surface with reticulate markings .. Heterodera Schmidt, 1871

Genus *Meloidogyne* Goeldi, 1887

About a decade earlier, the root-knot nematodes were generally referred to *Heterodera marioni* (Cornu, 1879) Goodey, 1932. In 1949, Chitwood assigned some root-knot nematode species to *Meloidogyne* Goeldi, 1887, and presented diagnostic characters for the separation of these species. Allen (1952) emended the diagnosis of the genus *Meloidogyne* and added further information about the morphology of this group. Skarbilovich (1959) has brought about many changes in the classification of Tylenchida. She has included 5 sub-families under Heteroderidae. The genus *Meloidogyne* Goeldi, 1887, has been assigned to a new sub-family, Meloidogyninae. However, for convenience, the author has not followed the lines of classification as proposed by Skarbilovich (1959).

The genus, at present, contains some 11 species, three of which have been reported to occur in India. The author has found *M. incognita* (Kofoid and White, 1919) Chitwood, 1949, and *M. javanica* (Treub, 1885) Chitwood, 1949, to be wide-spread in U. P. A large number of vegetable plants serve as congenial hosts for these species. Sometimes both the species were found to infest a particular plant host at one time. An example of this was seen in banana plants. The important phenomenon of the development of male within the swollen cyst of the larval cuticle was encountered in a population of *M. incognita* from bean roots.

Morphological details of the two species collected by the author are almost similar to the description of the same as

given by Chitwood (1949) and Allen (1952).

Meloidogyne incognita (Kofoid and White, 1919) Chitwood, 1949

Syn: Oxyuris incognito Kofoid and White, 1919

(Plate 16, Fig. A-F)

Male: 3 males: Length = 1.0-1.48 mm.; a = 47-54; b = 13-16; T = 46-63%.

Lip region with labial disc. Two faint striae on head. Lateral lips larger than sub-median, bearing crescentic apertures of oval amphids appearing as 'cheeks' in lateral view. Spear 23 μ long. Orifice of dorsal oesophageal gland 3.5 μ behind spear base. Testis single, outstretched. Spicula 29 μ long; gubernaculum 7 μ in length.

Female: 8 females: Length = 0.53-0.78 mm.; breadth = 0.3-0.54 mm.

Body swollen; neck elongate, variable in length. Head with distinct labial cap. Buccal spear weak 14-15 μ long; basal knobs rounded, slightly set off from shaft, 3.5 μ across. Orifice of dorsal oesophageal gland 2-3.5 μ behind spear base. Excretory pore located slightly behind spear base. Oesophageal glands free in body cavity. Vulva sub-terminal. Anus at edge of posterior lip of vulva. Transverse striae of body form a finger-print-like pattern on perineal region; striae of dorsal arch closely spaced, wavy. Transverse annulation in post-anal region a distinct whorl. Lateral grooves or ridges absent. Eggs 90-99 microns long by 34-40 microns broad.

PLATE 16

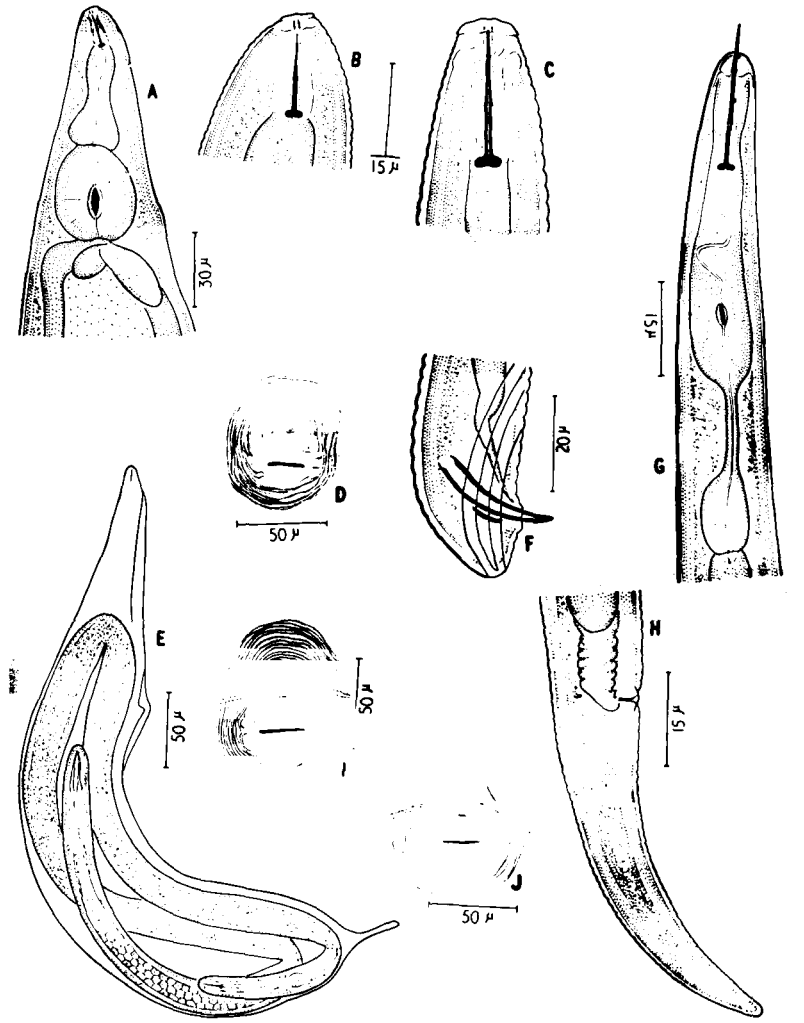


Plate 16. Figures A-F, Meloidogyne incognita. A. Oesophageal region of female; B. Head end of female; C. Head end of male; D. Perineal pattern; E. Metamorphosis of larva; F. Male tail. G-H, Paratylenchus sp. G. Oesophageal region of female; H. Posterior end of female. I-J, Perineal pattern of M. javanica.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Type host: Man (?). Probably a parasite of carrot.

Type locality: Texas.

Present hosts and distribution: A widely distributed species. It has been found causing gall-formation on the roots of the following plants in Aligarh.

Carica papaya L., Capsicum frutescens L., Cucumis sativus L., Cucumis melo L., Hibiscus rosa-sinensis L., H. esculentus L., Gossypium hirsutum L., Daucus carota L., Cucurbita pepo L., Delphinium sp., Coleus sp., Musa paradisiaca L., Nicotiana tabacum L., Solanum tuberosum L., S. melogena L., Raphanus sativus L. and Allium cepa L.

Meloidogyne javanica (Treub, 1885) Chitwood, 1949

Syn: Heterodera javanica Treub, 1885

(Plate 16, Fig. I-J)

Male: 2 males: Length = 1.13-1.15 mm.; a = 29-30; b = 11-13; T = 74-76%.

Transverse striae 2.2 µ apart. Lip region with set-off labial disc. Amphids large, oval, 4.5 µ long, opening through slit-like apertures. Spear 20-21 µ long. Orifice of dorsal oesophageal gland 3.5 µ behind spear base. Excretory pore at level of oesophago-intestinal junction. Testes two. Sperms 6 µ in diameter. Spicula strong, 30 µ long. Gubernaculum 8 µ in length. Tail short, rounded.

Female: Length = 0.53-0.92 mm.; breadth = 0.42-0.58 mm.

Transverse striae distinct, interrupted on lateral sides by groove-like fields formed by two incisures. Latter distinctly seen even in perineal region (Plate 16, Fig. I,J). Buccal spear 14-15.5 μ long; basal knobs rounded, set off from shaft, 4-5 μ across. Orifice of dorsal oesophageal gland 4-7 μ behind spear base. Excretory pore 42 μ from anterior end. Ovaries paired, coiled.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Type host: Saccharum officinarum L.

Type locality: Cheribon and Buitenzorg, Java.

Present hosts and distribution: A widely distributed species. Hosts recorded in Aligarh are: Carica papaya L., Cucurbita pepo L., Musa paradisiaca L., Brassica oleracea L.(Cabbage and cawliflower), Capsicum frutescens L., Hibiscus esculentus L. and Lycopersicon esculentum Mill.

Family Tylenchulidae Raski, 1957

Diagnosis: Tylenchoidea: Stylet of female well developed but not greatly enlarged. Head lightly sclerotized. Oesophagus consisting of well defined pre-corpus, corpus, isthmus, and glandular portion. Cuticle finely annulated. Females saccate, with one ovary. Bursa in male absent. Tails of both sexes elongate.

Type sub-family: Tylenchulinae Skarbilovich, 1947

Key to sub-families of Tylenchulidae

1. Excretory pore located much posterior to base of oesophagus ..... Tylenchulinae Skarbilovich, 1947
   Excretory pore normal, located near nerve ring ..... Sphaeronematinae Raski and Sher, 1952

Sub-family Tylenchulinae Skarbilovich, 1947

Diagnosis: Tylenchulidae: Excretory pore located posterior to normal position, much behind the base of oesophagus. Stylet in male degenerated.

Type genus: Tylenchulus Cobb, 1913.

Genus Tylenchulus Cobb, 1913

Diagnosis: Tylenchulinae: Stylet and oesophagus in male highly deteriorated. Female before metamorphosis a typical, active nema with functional vulva and uterus. Functional anus absent or may be present. Excretory pore located equatorially or post-equatorially. Male tail long, tapering to a bluntly rounded terminus. Development from egg to young adult free in soil.

Type species: Tylenchulus semipenetrans Cobb, 1913.

Key to species of Tylenchulus

1. Male tail less than 5 anal body diameters long; functional anus in female lacking .. semipenetrans Cobb, 1913
   Male tail about 7 anal body diameters long; functional anus in female present ..... mangenoti Luc, 1957

Tylenchulus semipenetrans Cobb, 1913

(Plate 17, Fig. A-F)

The citrus nematode, Tylenchulus semipenetrans Cobb, 1913, is world-wide in distribution. The author has collected specimens of this species in the states of Maharashtra, Madhya Pradesh and Uttar Pradesh of this country. Specimens have also been collected from W. Pakistan.

PLATE 17

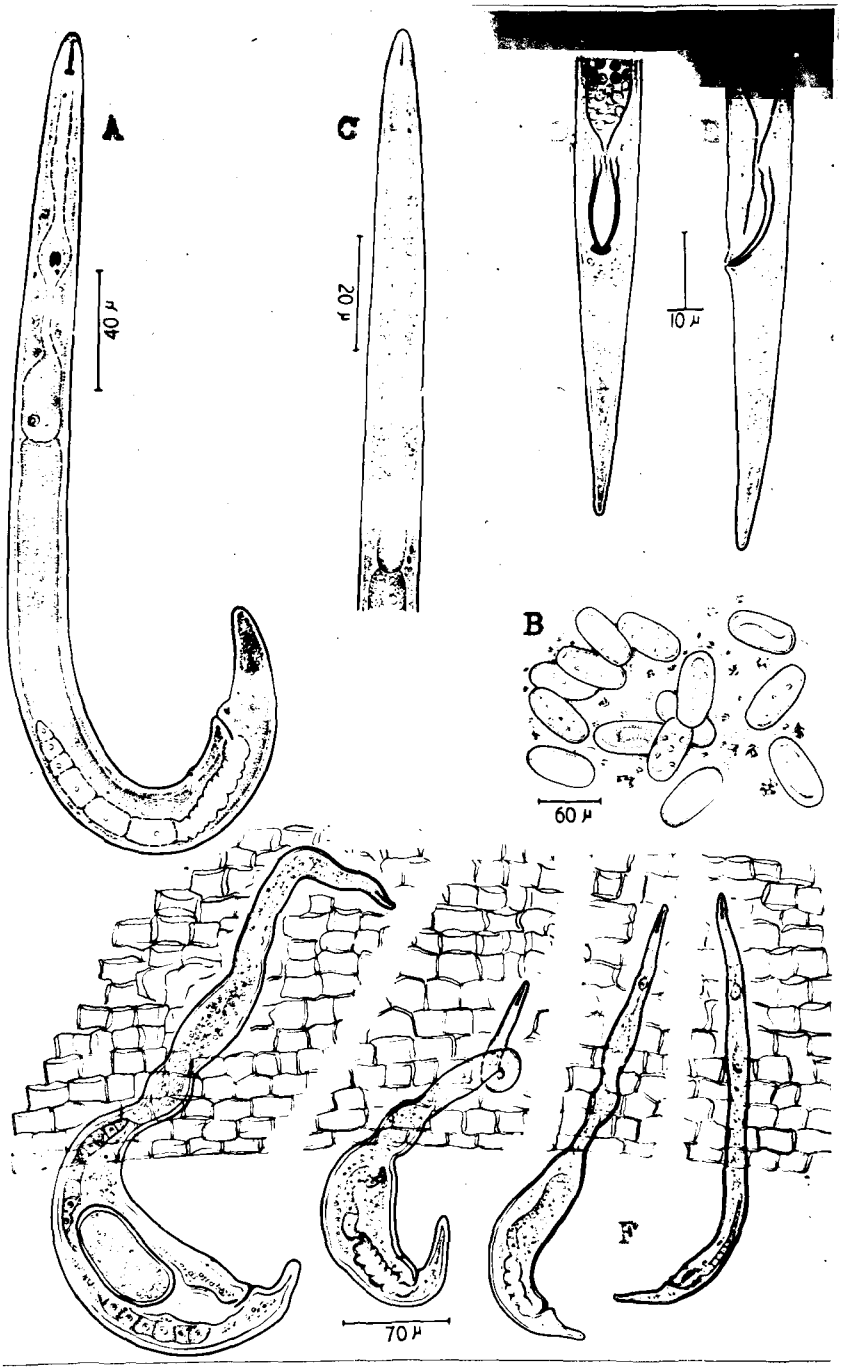


Plate 17. Figures A-F, Tylenchulus semipenetrans. A. Pre-adult female; B. Eggs in mucilage; C. Oesophageal region of male; D. Male tail, ventral view; E. Male tail, lateral view; F. Stages in the metamorphosis of female.

It is possibly widely distributed in Indo-Pakistan Sub-continent. As an important parasite of citrus trees, the species has been briefly described here. Morphological details conform closely to the description of the species given by Cobb, 1914. This is the first record of the parasite from India as well as Pakistan.

Young female: Length = 0.37 mm.; a = 18; b = 2.7; V = 27-90%.

Cuticle with rather coarse transverse striae. Cephalic frame-work hexa-radiate, moderately sclerotized. Spear 12 μ long, stout. Orifice of dorsal oesophageal gland 4 μ behind spear base. Oesophagus typically tylenchoid, with a powerful median oesophageal bulb. Excretory duct opening through a large, funnel-shaped pore located at 83% of the body from anterior end. Vulva a deep cleft. Ovary single, outstretched. Posterior extremity bluntly rounded. Anus not seen.

Adult female: The typical eel-like female provided with functional reproductive organs is fertilized by the male outside root tissues. It then penetrates its anterior end into the rootlet and undergoes metamorphosis. Ovary becomes mature and manifold. The funnel-like excretory pore becomes less prominent. Uterus becomes highly muscular and extended. Female becomes sedentary. Eggs laid in mucus, outside root.

Male: Length = 0.33 mm.; a = 36; b = 3.4; c = 8.6; T = 38%.

Spear and oesophagus degenerated. Excretory pore located in posterior half of body, at 72% of body length from

anterior end. Testis single, outstretched. Bursa absent. Spicules slender, 16 μ long. Gubernaculum simple, 3 μ long by 2.5 μ wide.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and geographical distribution: A cosmopolitan species almost solely confined to citrus family. At Aligarh it attacks Citrus limon (L.) Burm. and C. sinensis (L.) Osbeck. About 80% of citrus trees are found infested with this nematode. The author has also collected this species from citrus trees in Meerut, Nainital, Banda, Jhansi and Bulandshahr districts of U. P.; Bhopal (M. P.); Yeotmal (Maharashtra State); Lahore and Jhelum (W. Pakistan).

Diagnosis and relationship: Tylenchulus with the far posteriorly located excretory pore, anterior end devoid of cuticular wings, absence of a functional anus in female, and male tail measuring less than 5 anal body widths.

T. semipenetrans Cobb, 1913, can be differentiated from T. mangenoti Luc, 1957, the only other known species, by its female having a far posteriorly located excretory pore, absence of cuticular wings in the anterior end of the body, absence of a functional anus in female, and the male tail measuring less than 5 anal body diameters long as compared to about 7 anal body diameters long tail of the latter species.

Family Criconematidae Thorne, 1943

Diagnosis: Tylenchoidea: Cuticle usually heavily annulated or squamose. Spear in females and larvae strongly developed, elongated; in males of certain species reduced or absent. Median oesophageal bulb enlarged; isthmus reduced or absent; basal bulb much reduced. Vulva near posterior end of body; ovary single, prodelphic; post-vulvar uterine branch absent except in few species of Paratylenchus. Bursa may or may not be present.

Type sub-family: Criconematinae Taylor, 1936.

Key to sub-families of Criconematidae

1. Cuticle of female strongly annulated; isthmus absent, or short and broad ..... Criconematinae Taylor, 1936
   Cuticle finely annulated; isthmus narrow and distinct ..... Paratylenchinae Thorne, 1949

Sub-family Criconematinae Taylor, 1936

Diagnosis: Criconematidae: Body eel-like or fusiform. Cuticle heavily annulated, with or without spines or scales. Median oesophageal bulb greatly enlarged, fused with pre-corpus. Isthmus absent, or short and broad. Spear in males

may be lost in final moult. Bursa present or basent.

Type genus: Criconema Hofmänner and Menzel, 1914.

Key to genera of Criconematinae

1. Body robust, usually fusiform; body annules less than 200; spear with anteriorly reflexed basal knobs 2
   Body eel-like, with usually more than 200 annules; spear with rounded basal knobs .... Hemicycliophora de Man, 1921
2. Body annules in female smooth, without spines or scales.. 3
   Body annules in female crenate or with spines, scales or stalked appendages ..... Criconema Hofmänner and Menzel, 1914
3. Adult females ensheathed .... Hemicriconemoides Chitwood and Birchfield, 1957
   Adult females not ensheathed ..Criconemoides Taylor, 1936

Genus Criconema Hofmänner and Menzel, 1914

Syn: Iota Cobb, 1913
Ogma Southern, 1914

Diagnosis: Criconematinae: Body robust, fusiform, with thick annules. Posterior margins of annules bearing spines, scales, or stalked appendages; rarely crenate. Head annules usually modified. Spear much elongated, with anterior margins of basal knobs directed forward.

Type species: Criconema guernei (Certes, 1889) Hofmänner and Menzel, 1914

Key to species of Criconema

(Modified after Chitwood, 1957)

1. Posterior margins of body annules crenate, not bearing spines, scales or staked appendages..... ..... limitaneum Luc, 1959

   Posterior margins of body annules bearing spines, scales or stalked appendages 2

2. Annules 100 or more 3

   Annules less than 100 5

3. Annules about 150; spines short and wide .... squamosum (Cobb, 1913) Taylor, 1936

   Annules about 100-120 4

4. Spine slender, rod-like, in a continuous fringe .... pruni n. sp.

   Spines triangular, in 6 longitudinal rows .... guernei (Certes, 1889) Hofmänner and Menzel, 1914

5. Fringe continuous on each annule 6

   Fringe in strips or rows of distinct spines (not over 16 per annule) 9

6. About 120 spines on each annule on mid-body .... brevicaudatum n. sp.

   Less than 100 spines on each annule on mid-body 7

7. Annules numbering 45; 70-80 spines in continuous fringe . ..... multisquamatum (Kirjanova, 1948) Chitwood, 1957

   Annules numbering 53 or more; 40-60 spines in continuous fringe 8

8. Annules numbering 53; about 40 spines per annule .... fimbriatum (Cobb, unpubl.) Taylor, 1936

Annules numbering 60-70; about 60 spines per annule ... . menzeli (Stefanski, 1924) Taylor, 1936

9. Spines in a discontinuous fringe, arranged in longitudinal bands 10

Spines or scales in few (4-16) longitudinal rows 11

10. Spines in 8 longitudinal bands... civellae Steiner, 1949

Spines in 14 longitudinal bands.. tenuicaudatum n. sp.

11. Spines in only 4 longitudinal rows .... minutum (Kirjanova, 1948) Chitwood, 1957

Spines or scales in 8 or more longitudinal rows 12

12. Spines or scales in 16 longitudinal rows 13

Spines in 4-12 longitudinal rows 14

13. Body annules 62-64 in number .... cobbi (Micoletzky, 1925) Taylor, 1936

Body annules 46-54 in number .... coronatum (Stekhoven and Teunissen, 1938) Chitwood, 195

14. With 4-8 rounded scale rows .... lentiforme (Stekhoven and Teunissen, 1938) Chitwood, 1957

With 8, 10, 12 or 8-12 longitudinal rows of scales or spines 15

15. Scales in 8-12 or 12 longitudinal rows 16

Scales or spines in 8-10 longitudinal rows 17

16. Scales in 8-12 rows; rounded at side dentate or wholly trifid; 62 annules; stylet 82 microns .... tripium (Stekhoven and Teunissen, 1938) Chitwood, 1957

Scales in 12 longitudinal rows; bluntly triangular with side teeth, often somewhat tridentate; 42 annules; spear 98.5 µ .. tricodon (Stekhoven & Teunissen, 1938) Chitwood, 1957

17. Spines in 10 longitudinal rows; 86 annules .....
..... decalineatum Chitwood, 1957
Spines or scales in only 8 longitudinal rows 18

18. Spines mostly longer than wide 19
Spines mostly wider than long or about equal 20

19. Annules numbering 68-71; vulva at 15th annule from terminus ... murrayi (Southern, 1914) Taylor, 1936
Annules numbering 89; vulva at 17-18th annule from terminus ... spinalineatum Chitwood, 1957

20. Stylet 63 μ long; vulva at 12th annule from terminus
..... octangulare (Cobb, 1914) Taylor, 1936
Stylet 92 μ long; vulva at 10th annule from terminus
..... zernovi (Kirjanova, 1948) Chitwood, 1957

In 1913, Cobb described a new nematode, Iota squamosum, collected around mango roots at Bangalore, South India. This species was later transferred to the genus Criconema by Taylor (1936). It is the only species of Criconema known from India. Five species of this genus are being described hereunder, three of which are new to Science.

Criconema pruni n. sp.

(Plate 18, Fig. A-G)

Measurements: 25 females: Length = 0.56-0.75 mm. (0.61 mm.); a = 12-17 (14.4); b = 3.9-5 (4.4); V = 92.5-96% (94%); total body annules = 94-108 (100); spear = 66-74 microns (70 microns).

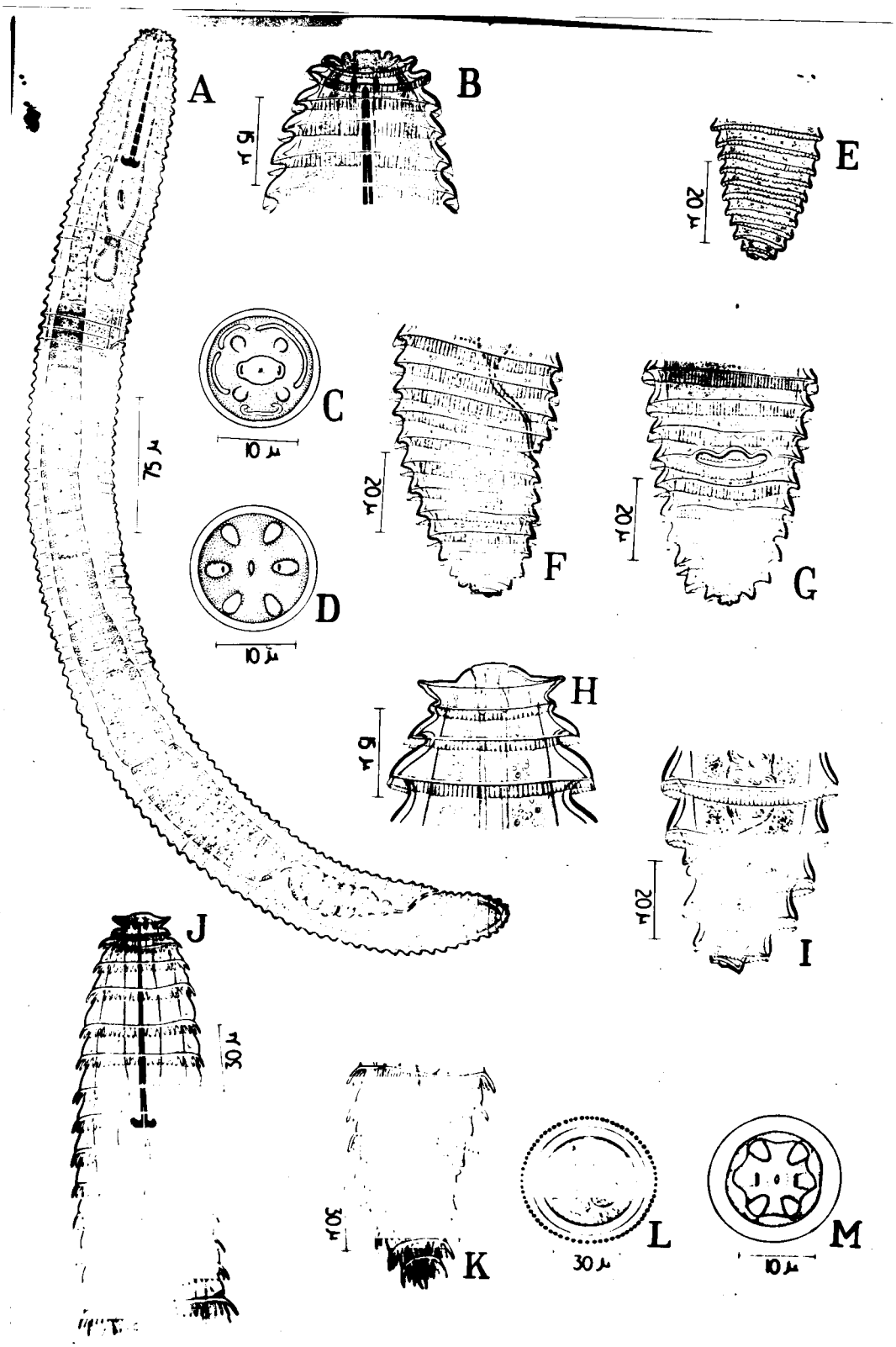
10 larvae: Length = 0.35-0.53 mm.; a = 12-14; b = 4-4.9; c = 21-25; total body annules = 80-107; spear = 52-62 microns.

Female (Holotype): Length = 0.65 mm.; a = 14; b = 4.5; c = 31; V = 82-94.3%.

Body almost cylindrical, assuming a slightly ventrally arcuate position on death. Body annules retrorse, numbering 106 and 103 on dorsal and ventral surface of body respectively. First annule not retrorse. Posterior margins of each annule bearing a continuous fringe of very fine spines, about 150 in number at mid-body and extending back to middle of following annule. In surface view, these annular fringes appearing as continuous, membranous flaps marked by deep longitudinal lines. Lateral fields or lines on body absent. Oral aperture obscure, located on an elevated labial disc bearing slit-like amphid apertures on its lateral margins. Sub-lateral lobes well developed, elevated, placed equidistantly around labial disc (Figure C). Cephalic sclerotization weak, hexa-radiate (Figure D).

Buccal spear strong, 71 microns long, with a 53 microns long tip. Basal knobs of spear measuring 11 microns across by 4.2 microns high, with outer margins directed forward. Outlet of dorsal oesophageal gland 7 microns behind spear base. Nerve ring enveloping short, narrow isthmus. Excretory pore on 29th annule

PLATE 18



from anterior end of body, 4 body annules posterior to oesophageal base.

Vulva a transverse slit, half as long as body width at that region, on 9th annule from terminus. Dorsal flap of vulva bilobed. Vagina leading upwards then inwards into a highly muscular uterus. Spermatheca absent. Ovary anteriorly outstretched; oöcytes in single row except for a few in region of multiplication. Distance from vulva to terminus approximately equal to vulvar body width. Rectum short, not very conspicuous. Anus located on 7th annule from terminus. Caudal end rounded, with last annule forming a button-shaped terminus.

Male: Not found.

Larvae: Body annules retrorse, with crenate, longitudinally lined posterior margins in all stages. Labial disc and sublateral lobes distinct. Anus on 4-7th annule from terminus.

Holotype: Female collected on 15th June, 1959; slide no. PN/C/1-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 24 females and 10 larvae; other data same as for holotype.

Type host: Collected from soil around roots of Prunus armeniaca L. (apricot).

Type locality: Ranikhet (elevation 6,000 feet), Almora District (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected around roots of apricot, Prunus armeniaca L., P. communis Huds., and Malus sylvestris (L.) Mill.

in Nainital and Almora districts of Uttar Pradesh (at an elevation of 5,500-6,500 feet) and P. armeniaca . at Simla (elevation 7,100 feet) in Punjab State.

Diagnosis and relationship: Criconema with body annules numbering 94-108, presence of continuous fringe of about 150 delicate spines on each annule at mid-body, buccal spear 66-74 μ long, and location of vulva at 7-10th annule from end of body. In having a continuous fringe of over 100 spines per annule C. pruni n. sp. resembles C. brevicaudatum n. sp. from which it can be separated by the presence of a larger number of body annules, distinct sub-lateral lobes around oral opening, and vulva located on 7-10th annule from terminus. In the general morphological characters, C. pruni is very close to Criconemoides xenoplax Raski, 1952, differing mainly in the presence of delicate, cuticular spines on body annules.

Criconema brevicaudatum n. sp.

(Plate 18, Fig. H-I)

Female (Holotype): Length = 0.49 mm.; a = 9.4; b = ?; c = sub-terminal; V = $^{48-}$92.4%.

Body cylindrical, tapering on either extremities, assuming a straight position on death. Body annules retrorse, 42 in number Each annule bearing on its posterior margins a continuous fringe of short, delicate spines numbering about 120 on middle of body. Head comprising of two, non-retrorse annules; the first

head annule saucer-shaped, 24 μ in diameter; the second being simple, 20 μ in width. Lip region cupolate; sub-lateral lobes indistinct. Buccal spear of stout built, 58 μ long; basal knobs 10 μ across, anteriorly reflexed. Oesophagus distorted. Excretory pore on 15th annule from anterior end.

Vulva a transverse slit, located on 5th body annule from terminus. Ovary single, anteriorly outstretched; oöcytes mostly arranged in single file. Vulvar body diameter greater than the distance from vulva to terminus. Anus obscure, possibly located on 2nd body annule from terminus. Last body annule small, button-shaped. Caudal end broadly rounded.

Male: Not found.

Holotype: Female isolated from soil sample collected by P. S. Narayanaswamy in September, 1958; slide no. PN/C/1-002; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Type host: Soil around roots of sugarcane, Saccharum officinarum L.

Type locality: Coimbatore (Madras State), South India.

Diagnosis and relationship: Criconema with 42 annules each bearing a continuous fringe of delicate spines numbering about 120 on mid-body, spear measuring 58 μ long, vulva located on 5th annule from end of body, and a broadly rounded caudal terminus.

Criconema brevicaudatum n. sp. is close to C. multisquamatum (Kirjanova, 1948) Chitwood, 1957, and C. pruni n. sp. It differs from the former in having a larger number of body spines per annule, shorter buccal spear, and the vulva located on the

5th annule from terminus; and from the latter in having a lesser number of body annules, absence of sub-lateral lobes in lip region, and the vulva located on 5th annule from end of body. It has also some affinities with Criconemoides boettgeri Meyl, 1954, which appears to be rather like a Criconema, from which it differs in having short, delicate spines on each annule and a smaller buccal spear (84.5 μ long in latter species).

Criconema multisquamatum (Kirjanova, 1948) Chitwood, 1957

Syn: Ogma multisquamata Kirjanova, 1948

Criconema fimbriatum (Cobb) Taylor of Sveshnikova, 1940

(Plate 18, Fig. J-M)

Kirjanova (1948) described this species as Ogma multisquamata Sp. N. from two female specimens which were collected by Sveshnikova around citrus roots. In those specimens the oesophageal structures and possibly the genital organs were not detectable. In the present study, however, sufficient material in good condition was available for examination. Hence the species is briefly re-described.

Measurements: 7 females: Length = 0.49-0.62 mm.; a = 9.4-14; b = 3.6-4; V = 28-70-90-91%; spear = 87-97 μ; total body annules = 44-48.

3 larvae: Length = 0.35-0.44 mm.; a = 12-13.3; b = 6-6.6; spear = 40-75 μ; total body annules = 43-47.

Female: Body cylindrical, straight, appearing dark-brown

in colour. Body annules averaging 45 in number, bearing a continuous fringe of about 72 rod-shaped spines per annule on middle of body. Structure of the head as described for C. brevicaudatum. En face view showing an oval oral opening surrounded by six confluent lips. Amphid apertures slit-like, located on inner margins of lateral lips. Spear stout, with well developed basal knobs. Median oesophageal bulb 22 μ wide at its widest. Isthmus short, enveloped by nerve ring. Posterior oesophageal bulb rounded. Excretory pore on 15th annule from anterior end, 2 body annules behind oesophageal base. Vulva on 7-8th annule from terminus. Spermatheca absent. Ovary prodelphic, with oöcytes arranged in single file except for a few near cap-cell which form double rows. Anus not located. Caudal end conoid-rounded.

Male: not found.

Larvae: Body similar to that of female. Annules with continuous fringe of spines as in female. Spear more slender than in female.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and localities: Specimens of this spècies have been collected from soil around roots of Prunus armeniaca L. and Malus sylvestris (L.) Mill. in Nainital and Almora districts of U. P. (at an elevation of 5,500-6,500 feet); P. armeniaca L. at Simla (elevation 7,100 feet) in Punjab State.

Diagnosis and ralationship: Criconema with 44-48 body annules bearing a continuous fringe of rod-like spines numbering about 72 on mid-body, spear 87-98 μ long, and vulva located on

7-8th annule from end of body. It comes close to C. fimbriatum (Cobb, unpubl.) Taylor, 1936, but differs in having a smaller number of body annules (44-48:53), more spines per annule on mid-body (72:40), and vulva located on 7-8th annule from terminus (on 10th annule in C. fimbriatum).

Criconema tenuicaudatum n. sp.

(Plate 19, Fig. A-D)

Measurements: 3 females: Length = 0.43-0.49 mm.; a = 10-10.4; b = 3.1-3.4; c = 15.6-15.8; V = 86-87.7%; total body annules = 59-61; spear = 106-110 microns.

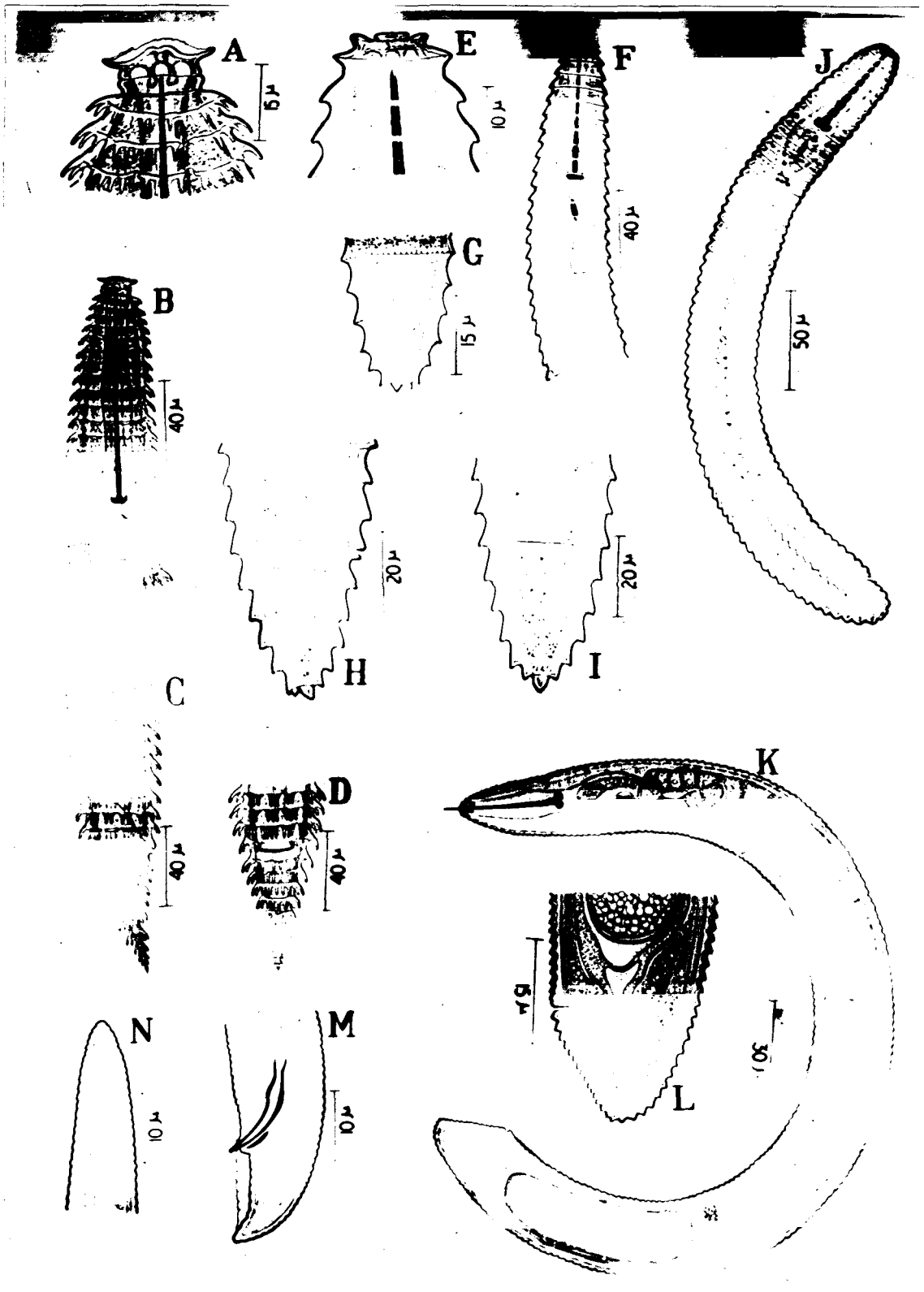
Female (Holotype): Length = 0.49 mm.; a = 10.4; b = 3.4; c = 15.8; V = 47-87.7%.

Body with thick dark cuticle, assuming a slightly ventrally arcuate position when the animal is killed by gradual heat. Body annules retrorse, 60 in number, bearing a discontinuous fringe of slightly curved spines having rounded ends on posterior margins. Spines arranged in groups of 2-3 (rarely 4) forming longitudinal bands numbering 14 on mid-body. Head distinctly set off from body, comprising two annules; the first cephalic annule anteriorly expanded to form a broad, membranous cup, 21 μ wide, enclosing the dome-shaped lip region; the second annule simple, 16 μ in width. Amphid apertures small, slit-like, located on lateral lips near oral opening.

Spear slender, much elongated, 106 μ long; spear tip 91 μ

Plate 19. Figures A-D, Criconema tenuicaudatum. A. Head end of female; B. Oesophageal region of female; C. Posterior end of female; D. Posterior end of female, ventral view. E-I, Criconemoides insigne. E. Head end of female; F. Oesophageal region of female; G. Posterior end of larva; H. Posterior end of female; I. Posterior end of female, ventral view. J. C. citri, female. K-N, C. parvulum. K. Female; L. Posterior end of female; M. Male tail, lateral view; N. Head end of male.

PLATE 19


A
50 μ
E
10 μ
F
40 μ
J
50 μ
G
15 μ
B
40 μ
H
20 μ
I
20 μ
C
40 μ
D
40 μ
K
50 μ
30 μ
L
N
10 μ
M
10 μ

in length; spear knobs anteriorly reflexed, 8.5 μ across and one-third as much high. Oesophagus extending through 22 body annules. Excretory pore on 24th body annule from anterior end. Nerve ring enveloping isthmus.

Vulva a transverse slit, located on 11th annule (10-11th annule in paratypes) from posterior end of body. Uterus with numerous small-sized sperms enclosed in a thin-walled spermatheca at its distal end. Ovary single, prodelphic, with oöcytes arranged in one row. Anus on 6th annule from terminus. Tail attenuated.

Male: Not found.

Holotype: Female collected on 10th June, 1959; slide no. PN/C/1-003; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 2 females; other data same as for holotype.

Type host: Soil about roots of Citrus limon (L.) Burm.

Type locality: Bhowali (elevation 5,500 feet), Nainital District (U. P.), India.

Diagnosis and relationship: Criconema with 59-61 annules, spines arranged in groups of 2-3 in longitudinal bands numbering 14 on mid-body region, 106-110 microns long spear, vulva located on 10-11th annule from posterior end of body, and an attenuated tail.

Criconema civellae Steiner, 1949, is the only other known species of the genus which bears longitudinal bands of spines on the body. C. tenuicaudatum n. sp. can easily be differentiated from it by its 14 longitudinal bands of spines on mid-body as compared to only 8 in C. civellae.

Criconema octangulare (Cobb, 1914) Taylor, 1936

Syn: Iota octangulare Cobb, 1914

Two female specimens of this species were collected around roots of apricot, Prunus armeniaca L. at Ranikhet, Almora District (U. P.), India, in June, 1959. A study on these specimens revealed the following formula:

Length = 0.43-0.47 mm.; a = 12-13; b = 4-4.5; c = 15.8-16; V = $^{60-66-}$86-87.3%.

The body bears 8 rows of scale-like structures on mid-region. It comparises of 73-74 annules; the first cephalic annule is angular, directed outward. The buccal spear measures 68-69 microns in length and the excretory pore lies on 23rd annule from anterior end of body. The vulva has a tri-lobed posterior flap. Other details conform closely to those given by Cobb, 1914, and Taylor, 1936.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis and relationship: Criconema with 65-75 body annules, body bearing 8 rows of scale-like spines, 63-69 µ long buccal spear, vulva located on 12th annule from posterior end of body, and a conoid caudal end. It comes close to C. zernovi (Kirjanova, 1948) Chitwood, 1957, from which it can be separated in having a shorter buccal spear (92 µ long in C. zernovi) and vulva located on 12th annule (on 10th annule in C. zernovi).

Genus Criconemoides Taylor, 1936

Generic diagnosis: Criconematinae: Body robust, usually fusiform. Spines, scale-like structures or stalked appendages on annules absent in adult female, may be present in larvae of certain species. Body annules less than 200 in number. Females not ensheathed. Spear elongate, with anteriorly reflexed basal knobs. Vulva near posterior end. Males with or without bursa.

Type species: Criconemoides morgense (Hofmänner and Menzel, 1914) Taylor, 1936.

Key to species of Criconemoides

(vide Raski, 1958)

Three species of the genus Criconemoides are being described here-under. Two of these are new to Science. This is the first record of this genus from India.

Criconemoides insigne n. sp.

(Plate 19, Fig. E-I)

Measurements: 5 females: Length = 0.4-0.53 mm.; a = 11-13; b = 4-4.6; c = 30-34.5; V = $^{40-82-}$91.7-93%; total

body annules = 65-69; spear = 60-64 μ.

Female (Holotype): Length = 0.5 mm.; a = 11.6; b = 4.5; c = 31; V = $^{66-}$92%.

Body cylindrical, with tapering ends, assuming a slightly ventrally arcuate position when killed by gradual heat. Body annules retrorse, 69 in number. Lateral lines or annular anastomoses absent. First two annules of anterior end not retrorse. Sub-lateral lobes not discernible. Amphid apertures small, slit-like, located on inner margins of elevated labial disc. Internal cephalic sclerotization fairly strong.

Spear 63 μ in length, with 50 μ long tip. Basal knobs of spear 9 μ across. Oesophagus extending through 18 body annules. Excretory pore on 22nd annule from anterior end. Vulva 15 μ long, slit-like opening, located on 7th annule from terminus. Spermatheca not observed. Ovary monodelphic, prodelphic. Distance from vulva to caudal terminus greater than vulvar body width. Anal aperture small, rounded, located on 4th annule from caudal terminus. Caudal end convex-conoid; last annule forming a conoid-rounded terminus.

Male: Not found.

Larva: Length = 0.39 mm.; a = 12; b = 4.3; c = 28.

Body annules retrorse, with crenate posterior margins, 73 in number. Excretory pore located on 20th annule from anterior end. Spear 42 μ long. Anus located on 5th annule from terminus.

Holotype: Female collected on 16th June, 1959; slide no. PN/C/2-001; deposited with the Zoology Museum, Aligarh Muslim

University, Aligarh (U. P.), India.

Paratypes: 4 females and 1 larva; other data same as for holotype.

Type habitat: Forest soil associated with roots of trees.

Type locality: Almora (elevation 5,500 feet), U. P., India.

Diagnosis and relationship: Criconemoides with a short body assuming a slightly ventrally arcuate position on death; body annules numbering 65-69; absence of lateral lines on body; spear measuring 60-64 μ in length; vulva and anus located on 6-7th and 4th annule respectively from caudal terminus; a convex-conoid caudal end, with the last annule forming a conoid-rounded terminus.

C. insigne n. sp. is close to C. anura (Kirjanova, 1948) Raski, 1958, from which it differs in having a larger number of body annules (65-69:60), presence of a labial disc in contrast to six, large lips in the latter species, a shorter buccal spear (70 μ long in C. anura), and anus located on 4th annule from terminus (on terminal annule in C. anura). It has some similarities with C. informe (Micoletzky, 1921) Taylor, 1936 from which it can be distinguished by having a more slender body, a larger number of body annules, a smaller buccal spear (71-81 μ long in C. informe), and distance from vulva to caudal terminus being greater than the body width at vulva.

Criconemoides parvulum n. sp.

(Plate 19, Fig. K-N)

Measurements: 20 females: Length = 0.27-0.32 mm.; a =

11-14; b = 3.8-4.6; c = sub-terminal; V = 35-80-93.8-95.2%; total body annules = 168-194; spear = 30-34 μ.

5 males: Length = 0.29-0.3 mm.; a = 19-22.5; b = ?; c = 19-21.5; T = 28-38%; spicula = 15-17 μ; gubernaculum=4-5 μ.

10 larvae: Length = 0.205-0.258 mm.; a = 11-12; b = 3.6-4.5; c = sub-terminal; total body annules = 168-180; spear = 20-22 μ.

Female (Holotype): Length = 0.3 mm.; a = 13; b = 4.2; c = sub-terminal; V = 79-95%.

Body assuming an open ring-shaped position when the worm is killed by gradual heat. Body annules retrorse, with angular posterior margins, numbering 170 on ventral and 175 on dorsal side. Head conoid, anteriorly flattened, continuous with body contour. Sub-lateral lobes absent. Lateral lines on body not seen.

Spear 32 μ long; spear shaft 9 μ in length, with three strong basal knobs measuring 4.5 μ across. Orifice of dorsal oesophageal gland 4 μ behind spear base. Excretory pore on 44th annule from anterior end, 4 annules behind oesophageal base.

Vulva a transverse slit, 10 μ long, located on 13th annule (on 12-15th annule in paratypes) from posterior end, leading into a thick-walled vagina. Latter at right angles to body axis, extending half-way into body. Uterine egg 55 μ long by 15 μ broad (50-60 by 15-17 μ in paratypes). Spermatheca present. Ovary single, extending up to corpus of oesophagus; distal end reflexed. Rectum and anus difficult to observe; latter on 6th annule from terminus.

Male (Allotype): Length = 0.29 mm.; a = 22.5; b = ?; c = 21; T = 30%.

Lip region conically elevated, marked by 4 striae. Labial frame-work faintly sclerotized. Body striae 1 μ apart. Buccal spear and oesophagus degenerated. Nerve ring 60 μ from anterior end. Excretory pore 12 μ posterior to level of nerve ring. Hemizonid 2 body annules long, located 3 annules anterior to excretory pore.

Testis single, outstretched. Spicula arcuate, cephalated, 16.5 μ long. Gubernaculum trough-shaped, 4.5 μ in length. Bursa distinctly crenate, beginning from level of head of spicula and completely enveloping tail. Latter conoid, with greater curvature occurring on its dorsal surface; terminus bluntly rounded.

Larvae: Annules retrorse, angular. Cuticular ornamentation absent. Caudal terminus broadly rounded, with angular retrorse annules.

Holotype: Female collected on 10th November, 1957; slide no. PN/C/2-002; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/C/2-003; other data same as for holotype.

Paratypes: Hundreds of females and 4 males; other data same as for holotype.

Type host: Citrus limon (L.) Burm.

Type locality: Aligarh (U. P.), India.

Distribution: This species is widely distributed in U. P. Specimens have been collected from soil around roots of C. limon in 8 districts of this State.

Diagnosis and relationship: Criconemoides with a small body bearing 168-194 annules, tapering sharply behind region of vulva; a short spear measuring 30-34 μ long, vulva located on 12-15th annule from terminus, and vagina leading inward at right angles to body axis.

C. parvulum n. sp. is closest to C. parvum Raski, 1952, and C. zavadskii (Tulaganov, 1941) Raski, 1958. It differs from C. parvum in having a larger number of body annules (142-156 annules in C. parvum), a smaller buccal spear (38-41 μ long in C. parvum), and vagina being at right angles to body axis. From C. zavadskii this species can easily be distinguished by the body annules being angular posteriorly and the vulva located on 12-15th annule from end of body (on 7-8th annule in C. zavadskii).

Criconemoides citri Steiner, 1949

(Plate 19, Fig. J)

Female: As originally described. The difference, however, can be noted in the lateral sides of the body appearing both plain as well as folded to form an irregular zig-zag line and the oesophagus being much shorter than that in female as illustrated by Steiner, 1949. The ranges of various measurements

of ten females are presented below:

Length = 0.28-0.36 mm.; a = 9.2-9.6; b = 3.2-3.3; c = ?; V = $^{40-83-93-95}$%; spear = 49-51 μ; uterine egg = 70 μ long by 21 μ broad.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and localities: Specimens of this species have been collected in Aligarh and Banda districts of U. P. from the following hosts: Citrus limon (L.) Burm.; Grewia asiatica L.; Mangifera indica L.; Cynodon dactylon Pers.

Diagnosis and relationship: Criconemoides with a small body, with 63-73 annules; buccal spear measuring 49-51 μ in length vulva located on 5th annule from posterior end, and the lateral lines on the body being simple breaks as well as folded to form a zig-zag line.

C. citri Steiner, 1949, is related to C. sphaerocephalum Taylor, 1936, and C. informe (Micoletzky, 1921) Taylor, 1936, from both of which it differs in having a shorter buccal spear. According to Raski (1958) this species keys to C. sphaerocephalum from which it has been separated by Raski in having a shorter buccal spear and lateral sides of body not forming a zig-zag line. Studies on the present specimens show that the lateral line in C. citri is variable, somewhere zig-zag and somewhere simple, with occasional breaks.

Genus Hemicriconemoides Chitwood and Birchfield, 1957

Diagnosis: Criconematinae: Adult female with fewer annules than in Hemicycliophora, ensheathed, with or without lateral grooves. Annules of sheath rather plain; those of body cuticle sometimes more numerous and difficult to count. Male not ensheathed, without functional stylet; bursa when present not well developed as in Hemicycliophora; spicules straight or arcuate but not as greatly curved as in Hemicycliophora. Basal knobs of spear in female anteriorly reflexed

Type species: Hemicriconemoides wessoni Chitwood and Birchfield, 1957.

Key to species of Hemicriconemoides

1. Female tail short, bluntly rounded ..... brachyurus (Loos, 1949) Chitwood and Birchfield, 1957
   Female tail conoid, conically rounded to rather bluntly attenuated 2
2. Sheath annules about 200 in number 3
   Sheath annules about 75-150 in number 4
3. Spear shaft 17 μ long; tail tip not distinctly set off ..... biformis Chitwood and Birchfield, 1957
   Spear shaft 20-25 μ long; tail tip distinctly set off ..... floridensis Chitwood and Birchfield, 1957
4. Sheath annules 75-83 .. wessoni Chitwood & Birchfield, 1957
   Sheath annules about 100-150 5

5. Sheath annules about 100 ..... cocophillus
(Loos, 1949) Chitwood and Birchfield, 1957
Sheath annules about 120-150 6
6. First head annule angular; male with caudal alae
..... mangiferae n. sp.
First head annule rounded; male without caudal alae
..... gaddi (Loos, 1949) Chitwood and Birchfield, 1957

Hemicriconemoides mangiferae n. sp.

(Plate 20, Fig. A-K)

Measurements: 25 females: Length = 0.41-0.6 mm.; a = 19-23; b = 3.6-4.8; c = 18-24; V = 36-69-91-93%; total body annules = 133-148; spear = 70-81 µ.

8 males: Length = 0.4-0.44 mm.; a = 26-31; b = 4-4.5; c = 14-17; T = 30-44%; spicula = 24-28 µ; gubernaculum = 4.5-5 µ.

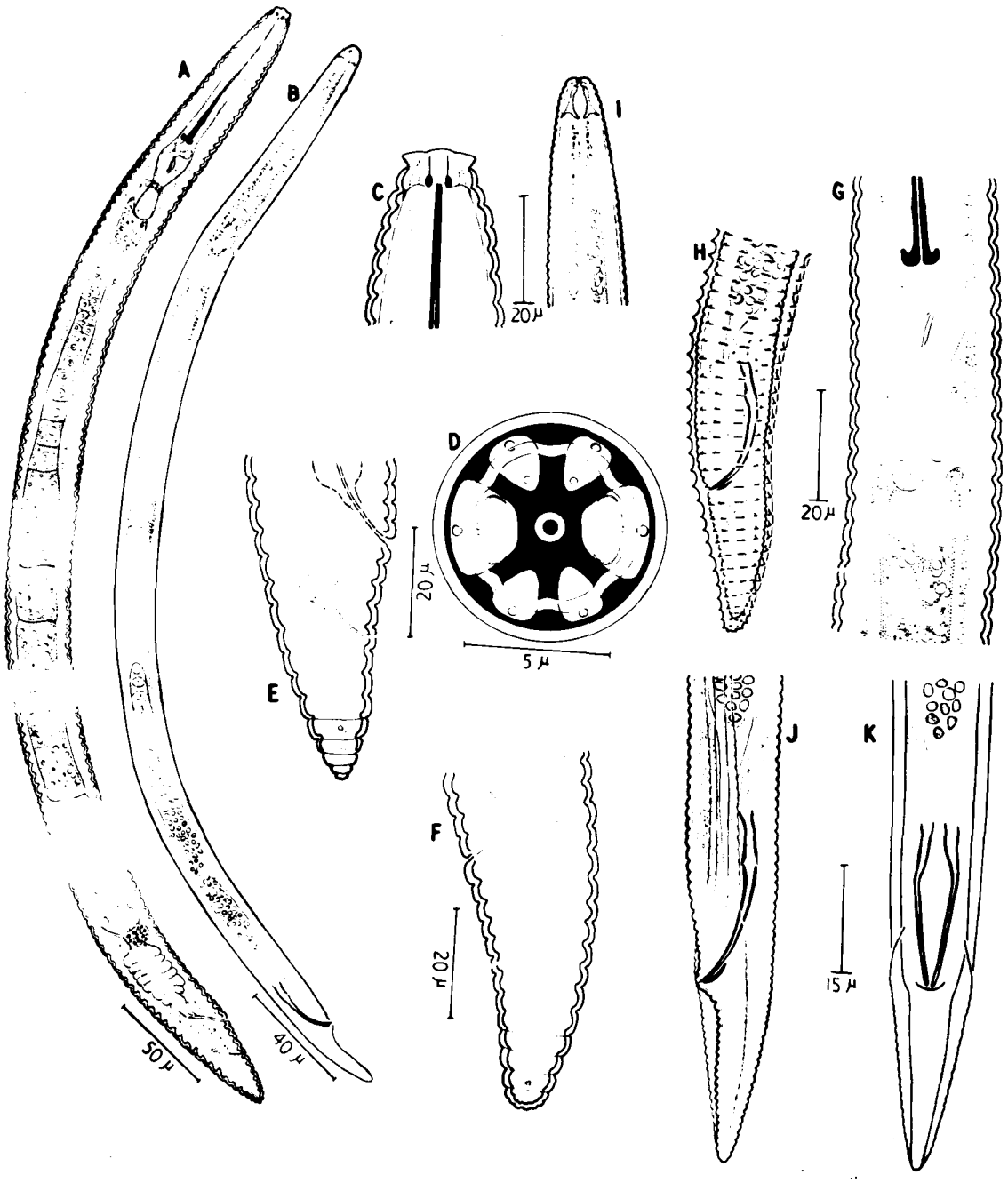
Female (Holotype): Length = 0.59 mm.; a = 22; b = 4.8; c = 22.5; V = 68-92.5%.

Body cylindrical, tapering evenly at both ends, covered by a cuticular sheath attached to it at its extremities and in the region of vulva. Body annules coarse, 137 in number, corresponding in number with those on the sheath. Lateral lines or grooves absent. First annule of head angular, directed outward.

Spear 74 µ long; its tip measuring 64 µ in length; basal knobs strong, 7 µ across by 3 µ high, with anterior margins directed forward. Outlet of dorsal oesophageal gland 7 µ behind

Plate 20. Figures A-K, *Hemicriconemoides mangiferae*. A. Female; B. Male; C. Head end of female; D. *En face* view; E. Posterior end of female; F. Posterior end of female with rounded terminus; G. Oesophagus and excretory pore in female; H. Posterior end of ensheathed male; I. Head end of male; J. Posterior end of male, lateral view; K. Posterior end of male, ventral view.

PLATE 20



spear base. Excretory pore on 36th annule from anterior end, 4th annule posterior to oesophageal base.

Vulva transverse, 11 μ long, on 13th annule from terminus. Spermatheca with numerous sperms present. Ovary prodelphic. Uterine eggs in paratypes 67-71 μ long by 16-18 μ broad. Rectum and anus not easily visible. Latter located on 9th annule from terminus. Tail elongate conoid, with terminal annule smoothly rounded. Tail end rounded in some of paratype females (Fig. F).

Male (Allotype): Length = 0.41 mm.; a = 27; b = 4.1; c = 16; T = 36%.

Body striae 1.4 μ apart. Sheath absent. Lateral fields with 4 incisures, one-fourth as wide as body. Lip region conoid, marked by 5 striae. Spear lacking. Hemizonid 3 body annules long, 84 μ from anterior end. Excretory pore 4 body annules posterior and nerve ring one body diameter anterior to hemizonid. Oesophagus degenerated.

Testis single, outstretched. Spicules 26 μ long, arcuate, cephalated. Gubernaculum simple, 4.5 μ long and approximately as much wide. Bursa with crenate margins, beginning slightly anterior to cloaca and ending just near tail terminus. Tail rather cylindrical, slightly tapering to a rounded terminus, shorter in length than the spicula.

Ensheathed male: Head similar to that in adult. Body bearing a loose sheath ornamented with 12 longitudinal rows of scale-like spines. Oesophagus obscure. Testis well developed. Spicula 25 μ long; gubernaculum 4.5 μ in length.

Larvae: Body similar to that of female. Body cuticle bearing 12 longitudinal rows of pointed, scale-like spines.

Holotype: Female collected on 26th November, 1957; slide no. PN/C/3-001; deposited with the Zoology Museum, Aligarh Muslim University; Aligarh (U. P.), India.

Allotype: Male collected on December 21, 1957; slide no. PN/C/3-002; other data same as for holotype.

Paratypes: Hundreds of females and 7 males; other data same as for holotype.

Type host: Mangifera indica L. (mango tree).

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected from soil around roots of mango trees in Aligarh, Allahabad, Banda, Bareilly, Bulandshahr, Meerut, Nainital, and Pilibhit districts of U. P., Jabalpur (M. P.); Citrus limon (L.) Burm. in Aligarh, Banda, Badaun (U. P.); Citrus reticulata Blanco in Aligarh and Badaun (U. P.), and Yeotmal (Maharashtra State); Grewia asiatica L. in Aligarh; Prunus armeniaca in Nainital (U. P.).

Diagnosis and relationship: Hemicriconemoides with body annules numbering 133-148, first head annule angular, spear 70-80 μ in length, vulva situated on 13th annule from terminus, dimorphic condition of the female tail, and the male with a crenate bursa and a cylindroid tail.

H. mangiferae n. sp. comes closest to H. gaddi (Loos, 1949) Chitwood and Birchfield, 1957, but can be separated from it by its female having a larger number of body annules (about 120 in H. gaddi), the first head annule being angular in shape, and more posteriorly located excretory pore, and by its male having wider lateral fields bearing 4 incisures, and a shorter, cylindroid tail and the presence of a bursa.

Hemicriconemoides cocophillus (Loos, 1949) Chitwood and Birchfield, 1957

Syn: Criconemoides cocophillus Loos, 1949

(Plate 21, Fig. A-B)

This species was originally described by Loos (1949) as Criconemoides cocophillus sp. nov. collected from soil around grass and coconut roots in Kurunegala, Ceylon. The specimens collected in India conform closely with the description of the species as given by Loos. However, there is some difference in the structure of the body behind the region of the vulva. In the present specimens the tail end is convex-conoid with a rounded terminus and, although, Loos has also described the tail end in his specimens as convex-conoid but his diagram shows it in a different way. Its terminus appears to be rather digitate. Inspite of this difference, because all other structures are the same, the present specimens have been placed in H. cocophillus. The variations recorded in the measurements and counts of certain structures are presented below.

Measurements: 12 females: Length = 0.43-0.53 mm.; a = 14-19; b = 4-5.4; V = $^{32-70-}$92-94.3%.

Body annules 98-126 in number. Buccal spear 49-58 µ long. Excretory pore located 30-36th annule from anterior end of body, 6-11th annule posterior to oesophageal base. Vulva with lateral cuticular flaps, located on 9th annule from terminus (9-13th). Tail convex-conoid, with greater curvature occurring on its dorsal side, ending in a rounded terminus. Caudal terminus not attached to body sheath.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and localities: Specimens of this species have been collected from soil around roots of Carissa sp. growing in hilly regions of Karwi, Banda District (U. P.) and sugarcane at Coimbatore (Madras State), South India.

Genus Hemicycliophora de Man, 1921

Syn: Procriconema Micoletzky, 1925

Diagnosis: Criconematinae: Body eel-like, usually with more than 200 annules, covered with a cuticular sheath (Rarely the sheath is absent). Spear elongated; basal knobs rounded, not reflexed. Anterior intestinal diverticulum absent. Male not ensheathed; with a large bursa. Spicules semicircular or occasionally slightly arcuate.

Type species: Hemicycliophora typica de Man, 1921.

Key to species of Hemicycliophora

(after Thorne, 1955)

1. Female without a body-sheath .....
..... longicaudata Loos, 1948

Female with a body-sheath 2

2. Body annules less than 200 in number 3
   Body annules 200 or more in number 4
3. Sheath with about 20 longitudinal rows of rectangular blocks ..... tesselata Sauer, 1958
   Sheath without longitudinal rows of rectangular blocks ..... brevicauda Sauer, 1958
4. Head annules distinctly separated .... hesperis Raski, 1958
   Head annules not separated 5
5. Caudal terminus acute or sub-acute 6
   Caudal terminus blunt, rounded 25
6. Length about 0.4 mm. .... straeleni de Coninck, 1931
   Length over 0.5 mm..... 7
7. Tail long attenuated 8
   Tail not attenuated 10
8. Neck cylindroid to truncate lip region 9
   Neck tapering to rounded lip region .... gigas Thorne, 1955
9. Body annules about 400 ... micoletzki (Goffart, 1948) Goffart, 1952
   Body annules 256-263 ..... paradoxa Luc, 1958
10. Body slender; a = 33-36 11
    Body more robust; a = 19-26 12
11. Length of body 1.0 mm. .....arcuata Thorne, 1955
    Length of body 1.4 mm. ..... tenuis Thorne, 1955
12. Body marked with numerous longitudinal striae 13
    Body not marked by longitudinal striae 16

13. Tail uniformly conoid 14
Tail not uniformly conoid 15

14. Lateral fields with a single row of rectangular blocks ..... penetrans Thorne, 1955
Lateral fields with double rows of rectangular blocks.. ..... oostenbrinki Luc, 1958

15. Body with about 200 annules ..... membranifer (Micoletzky, 1925) Thorne, 1955
Body with over 300 annules ..... indica n. sp.

16. Cuticle ornamented with delicate longitudinal markings ..... aquaticum (Micoletzky, 1913) Loos, 1948
Cuticle not ornamented with longitudinal markings 17

17. Body tapering uniformly from vulva to sub-acute terminus 18
Body not tapering uniformly from vulva to terminus ... 21

18. Vulva-terminus distance 3 times spear length .... parvana Tarjan, 1952
Vulva-terminus distance twice or less as long as spear.19

19. Lip region narrowed, rounded .... uniformis Thorne, 1955
Lip region broad, truncated 20

20. Lateral fields marked by 2 incisures.. conidia Thorne, 1955
Lateral fields without incisures .. pauciannulata Luc, 1958

21. Length about 1.2 mm. 22
Length about 1.7 mm. ..... gracilis Thorne, 1955

22. Males abundant..... typica de Man, 1921
Males as far as known absent 23

23. Body narrowing rapidly behind vulva... thienemanni (Schneider, 1922, 1925) Loos, 1948
Body not narrowing rapidly behind vulva 24

24. Spear 90-104 μ long ..... similis Thorne, 1955
Spear 112-122 μ long ..... vidua Raski, 1958

25. Terminus convex or irregularconoid to blunt terminus .. 26
Terminus hemispheroidal 31

26. Head set off by a constriction .... truncata Colbran, 1956
Head not set off by a constriction 27

27. Tail uniformly convex-conoid 28
Tail irregularly conoid to blunt terminus 30

28. Vulva-terminus distance less than spear length 29
Vulva-terminus distance more than spear length .....
..... obesa Thorne, 1955

29. Spear 116-120 μ long .... brevis Thorne, 1955
Spear 69-83 μ long ..... epicharis Raski, 1958

30. About 20 annules between vulva and terminus .....
..... aberrans Thorne, 1955
About 55 annules between vulva and terminus .....
.....striatula Thorne, 1955

31. Length 1.2 mm. ..... rotundicauda Thorne, 1955
Length about 0.8 mm. 32

32. Body with ventral contraction at vulva 33
Vulva continuous with body contour .. nana Thorne, 1955

33. Spear 86-100 μ long ..... arenaria Raski, 1958
Spear 120 μ long ..... obtusa Thorne, 1955

Hemicycliophora indica n. sp.

(Plate 21, Fig. C-F)

Measurements: 12 females: Length = 1.01-1.12 mm. (1.07 mm.) a = 26-31 (28.4); b = 5.9-6.9 (6.4); c = 11-12.6 (11.6); V = 81-83.8% (82.8%); total body annules = 306-316 (310); spear = 80-86 μ (81.4 μ).

12 larvae: Length = 0.57-0.84 mm.; a = 24-28; b = 4.5-5.6; c = 6.9-8.5; spear = 61-72 μ.

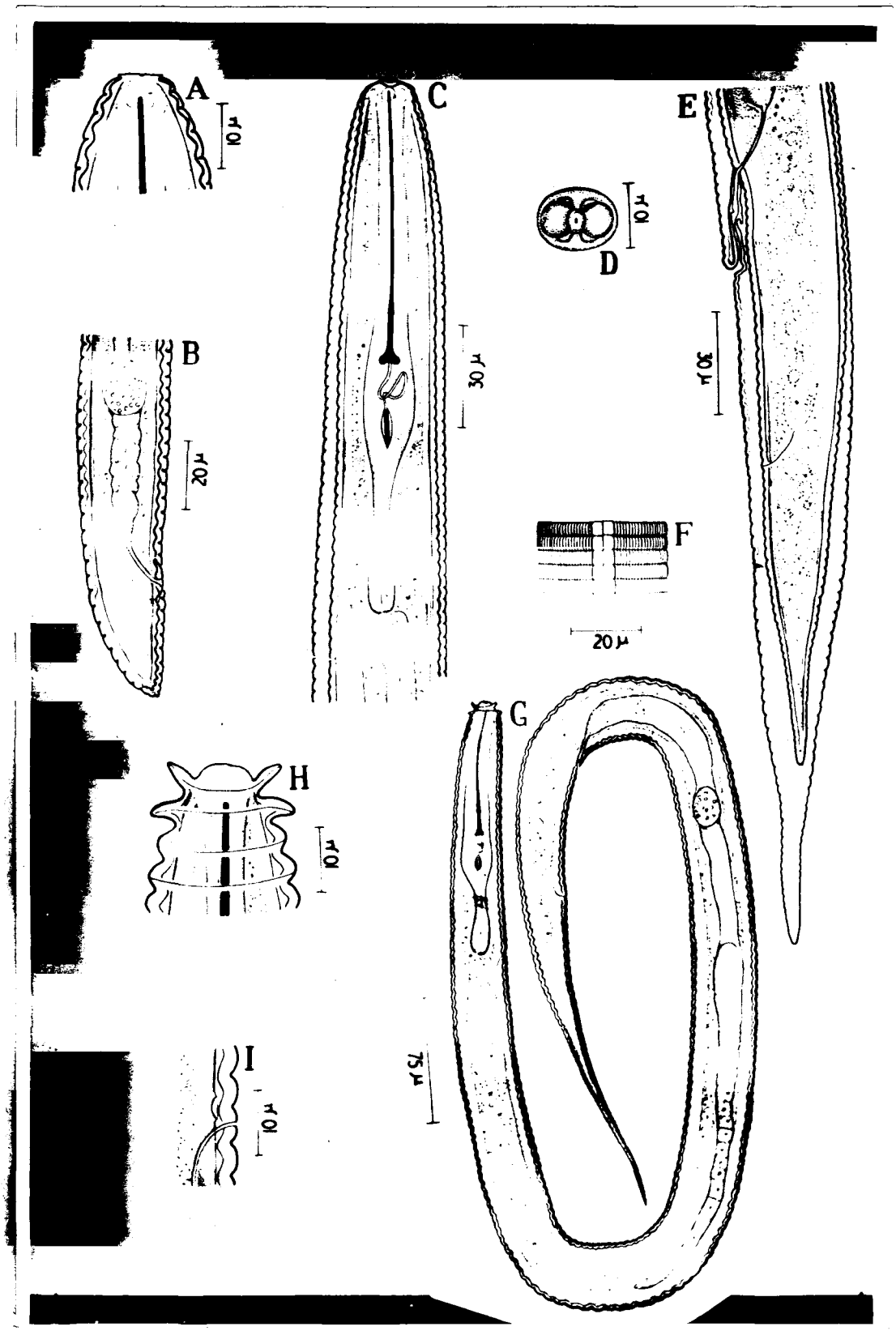
Female (Holotype): Length = 1.07 mm.; a = 30; b = 6.8; c = 12.3; V = 37-83.6%.

Body assuming a ventrally arcuate position when killed by gentle heat. Body annules 310 in number. Sheath fitting loosely about the body, marked by numerous (about 80 near middle of body) longitudinal lines. Lateral fields with two rows of rectangular blocks, one-fifth (one-fifth to one-sixth in paratypes) as wide as the body width. Head rounded, 12 μ in diameter, continuous with body contour, bearing 2 annules. Labial disc elliptical, about one-third as long as labial diameter (Fig. D).

Spear 80 μ in length; its basal knobs smoothly rounded, 6 μ across. Orifice of dorsal oesophageal gland 5 μ behind spear base. Isthmus a bit elongate, regularly expanding to form a basal oesophageal bulb, crossed by nerve ring. Hemizonid absent. Excretory pore on 51st annule from anterior end of body, on 4th annule behind oesophageal base.

Vulva about 64 body annules anterior to terminus, attached

PLATE 21



to the sheath through a long cuticular tube. Uterus elongate, wit a distal swelling, without any sperms. Ovary single, anteriorly outstretched. Rectum reduced; anus apparently functional, located at about middle of the distance from vulva to terminus. Tail at first convex-conoid then elongate-conoid to end in a finely rounded terminus, approximately 4 anal body diameters in length.

Male: Not found.

Larvae: Longitudinal lines on sheath present in all stages. Body annules greater in number than in females. Tail elongate-conoid, ending in a finely rounded terminus.

Holotype: Female collected on 26th December, 1959; slide no. PN/C/4-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 11 females and 12 larvae; other data same as for holotype.

Type host: Soil around roots of Carissa sp. growing in hilly regions.

Type locality: Karwi, Banda District (U. P.), India.

Diagnosis and relationship: Hemicycliophora with body averaging 1.07 mm in length and bearing over 300 annules, body sheath marked by about 80 longitudinal striae on mid-body, narrow lateral fields with double rows of rectangular blocks, 80-86 microns long buccal spear, absence of a hemizonid, and the elongate, not uniformly tapering tail.

Besides H. indica n. sp., there are three other Hemicycliophora spp. which bear longitudinal lines on body

sheath. These are: H. membranifer (Micoletzky, 1925) Thorne, 1955, H. penetrans Thorne, 1955, and H. oostenbrinki Luc, 1958. From the first of these the present species differs in its larger body-size, greater number of body annules (av. no. 200 in H. membranifer), more longitudinal lines on sheath, and much narrowed lateral fields; and from the other two, besides some other morphological characters, in having over 300 body annules, a not uniformly tapering tail, and the absence of a hemizonid.

Hemicycliophora longicaudata Loos, 1949

(Plate 21, Fig. G-I)

H. longicaudata Loos, 1948, is a peculiar species in that the females lack a body sheath and the males possess rather straight spicules in contrast with the semi-circular spicules of the other species. However, similar type of spicules have been reported to occur in H. paradoxa Luc, 1958. The studies conducted on the present specimens add further information about those structures which have not hitherto been recorded in this species. Of importance is the size and the form of the head annules which are large and distinctly separated from the body contour — a condition found only in H. hesperis Raski, 1958, and the occurrence of the hemizonid.

Measurements: 2 females: Length = 0.99-1.1 mm.; a = 27-

33; b = 7.3-7.4; c = 5.2-5.6; V = 73-74.3%; spear = 73-74 μ;
1 larva: Length = 0.74 mm.; a = 30; b = 5.8; c = ?

Body assuming a semi-circular position when the worm is killed by gradual heat. First two annules from anterior end modified in being larger than and well separated from the preceding ones; anterior annule directed forward and outward and posterior outward and downward. Cuticular ornamentation and lateral fields absent. Orifice of dorsal oesophageal gland 8 microns behind spear base. Excretory pore located near oesophageal base, on 33rd annule from the anterior end. Hemizonid poorly developed, located just anterior to the excretory pore. A spherical spermatheca with numerous sperms present in the distal end of uterus. Rectum one-half anal body width long, appearing as a refractive line in lateral view. Anus located on 18th annule from vulva.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Host and locality: Isolated from soil sample collected in September, 1958 around roots of Saccharum officinarum L. in Coimbatore (Madras State), South India.

Diagnosis and relationship: Hemicycliophora with a long body, without a sheath; well separated annules of the head; 73-74 μ long buccal spear; and an attenuated, filiform tail. The species is distinctive from all the known species of the genus in the absence of a body-sheath and a long, filiform tail which is annulated up to terminus.

Sub-family Paratylenchinae Thorne, 1949

Diagnosis: Criconematidae: Cuticle finely striated. Female an active nema (Paratylenchus) or obese (Cacopaurus). Adult female and larval spear elongated, slender; male spear reduced or lacking. Bursa absent.

Type genus: Paratylenchus Micoletzky, 1922.

Genus Paratylenchus Micoletzky, 1922

Diagnosis: Body eel-like. Cuticle finely striated. Spear elongated, with rounded basal knobs. Ovary single, outstretched anteriorly. Posterior uterine branch usually absent. Male stylet inconspicuous or lacking. Spicula tylenchoid. Gubernaculum simple. Bursa absent. Other characters as for sub-family.

Type species: Paratylenchus macrophallus (de Man, 1880) Goodey, 1934.

Paratylenchus sp.

(Plate 16, Fig. G-H)

The author collected 5 females of a species of Paratylenchus from soil around roots of Phoenix sp. at Aligarh (U. P.). A keen search for male specimens was made but without success. Thorne and Allen (1950) and Jenkins and Taylor (1956) classified Paratylenchus spp. into three groups according to the male characters. Unfortunately, in the present case, males were not

Family Neotylenchidae Thorne, 1949

Diagnosis: Tylenchoidea: Median oesophageal bulb with its valvular apparatus absent. Labial frame-work in either six or eight sectors. Basal portion of oesophagus variable. Bursa present, rarely absent.

Key to sub-families of Neotylenchidae

1. Labial frame-work octagonal... Neotylenchinae Thorne, 1941
   Labial frame-work hexagonal 2
2. Basal oesophageal bulb forming a stem-like basal extension ..... Paurodontinae Thorne, 1941
   Basal oesophageal bulb not forming a stem-like extension ..... Nothotylenchinae Thorne, 1941

Sub-family Neotylenchinae Thorne, 1941

Diagnosis: Neotylenchidae: Body with a dense texture which usually obscures anatomical details. Lip region low, octagonal, supporting frame-work in eight sectors, some of which may be greatly modified. Corpus cylindrical, without a valvular, median oesophageal bulb. Dorsal oesophageal gland often greatly developed. Ovary prodelphic. Post-uterine branch rarely present. Spicula tylenchoid to aberrant types. Gubernaculum present or absent.

Type genus: *Neotylenchus* Steiner, 1931

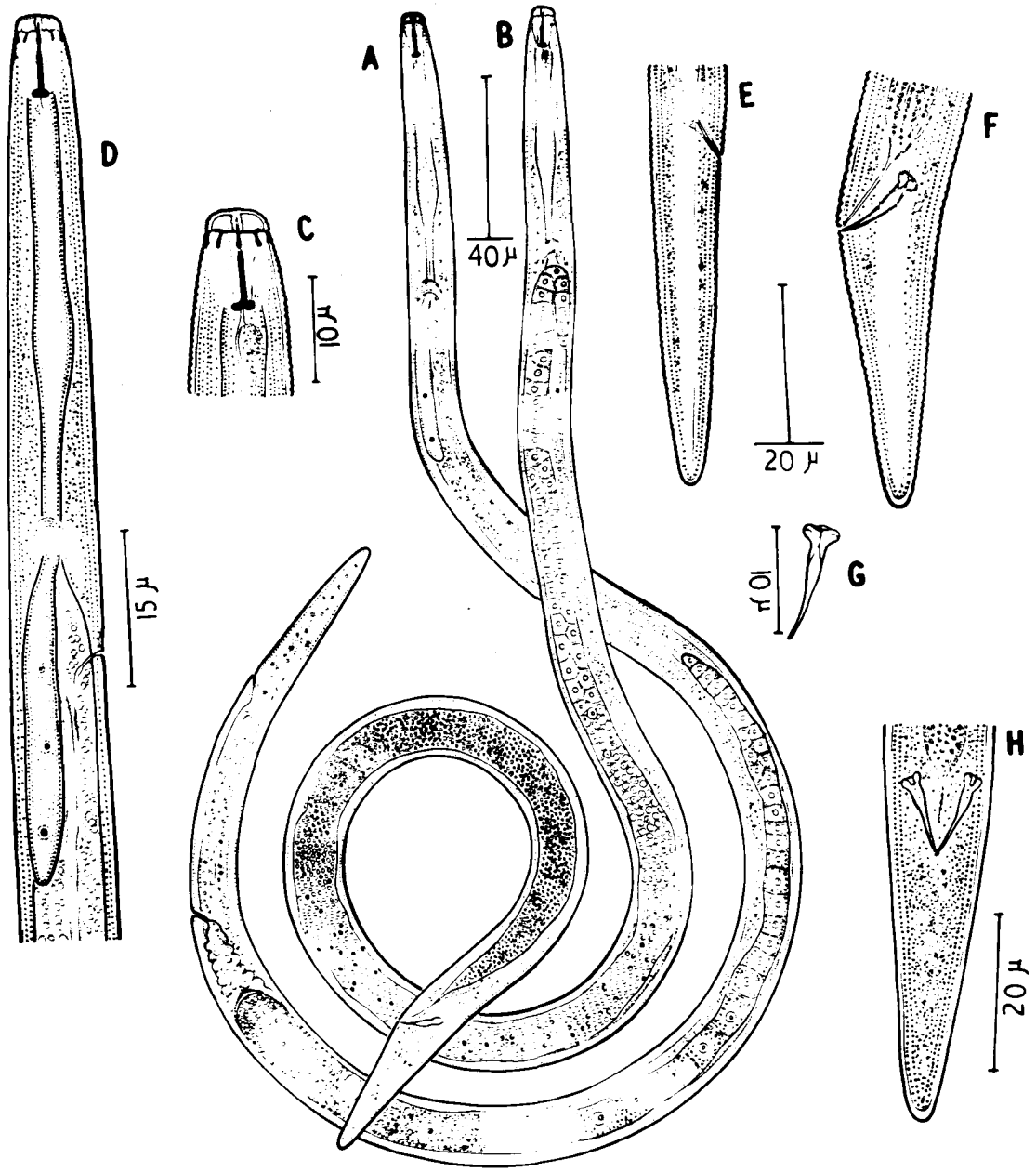
Key to genera of Neotylenchinae

1. Oesophageal base fused with intestine, not set off in any manner ..... Hexatylus Goodey, 1926
   Oesophageal base set off, bulb-like or with greatly developed glands 2
2. Oesophageal glands enclosed in the basal oesophageal bulb ..... Neotylenchus Steiner, 1931
   Oesophageal glands not enclosed, lying free in body cavity 3
3. Vulva located less than 10 per cent of body from posterior terminus, male tail enveloped by a bursa .....Deladenus Thorne, 1941
   Vulva located more than 10 per cent of body from posterior end, bursa absent .... Nuditylenchus n. g.

Nuditylenchus n. g.

Diagnosis: Neotylenchinae: Body less than 1 mm. long, slender, marked by fine transverse striae. Lateral fields with 4 incisures. Deirids and phasmids not observed. Labial framework octagonal, sclerotized. Buccal stylet well developed, about 10 μ in length, with three well developed, rounded basal knobs. Orifice of the dorsal oesophageal gland near base of spear. Precorpus a cylindrical tube, bearing a valveless basal swelling. Median oesophageal bulb absent. Isthmus

PLATE 22



Female (Holotype): Length = 0.54 mm.; a = 36; b = 7.5; c = 12.8; V = ^{48}-81.5%.

Body slender, eel-like, tapering sharply at ends. Cuticle bearing transverse striae measuring 0.9 µ apart on middle of body. Lateral fields narrow, with 4 incisures. Deirids and phasmids not observed. Lip region marked by 4 transverse striae, set off cap-like from body. Labial frame-work octaradiate, lightly sclerotized. Outer margins of labial frame-work conspicuous, extending 3 body annules into body.

Buccal spear of moderate strength, 10 µ long. Basal knobs of spear rounded, 2.5 µ across. Orifice of dorsal oesophageal gland 2 µ behind spear base. Precorpus a cylindrical tube, with a spindle-shaped, valveless swelling at base. Muscular corpus or median oesophageal bulb with its valvular apparatus absent. Isthmus narrow, cylindrical, joined imperceptibly with the intestine. Basal oesophageal bulb absent. Oesophageal glands lying free in body cavity, extending back over anterior end of intestine. Nerve ring enveloping isthmus just anterior to oesophago-intestinal junction. Excretory pore located 10 µ posterior to level of nerve ring. Hemizonid 3 body annules long, 2 body annules anterior to excretory pore. Intestine with well marked lumen, with spherical, refractive granules.

Vulva a transverse slit, located in posterior third of body. Vagina about one-third vulvar body width, leading inward and forward. Uterus highly muscular and folded. Ovary single, prodelphic; oöcytes arranged in single file except in a short region of multiplication. Post-uterine branch

absent. Vulva-anus distance greater than tail length.

Intestine ending in a short rectum, about half as long as maximum width of body. Anus distinct. Tail about three-and-a-half times anal body diameter in length, cylindrical, regularly tapering to a conoid-obtuse terminus.

Male (Allotype): Length = 0.55 mm.; a = 36.2; b = 8.3; c = 15.7; T = 82%.

Body similar to that of female but almost cylindrical upto tail in the posterior region. Buccal stylet 9.5 μ in length. Testis single, outstretched, with tip reflexed back, reaching up to oesophago-intestinal junction. Spermatocytes first arranged in single then in double rows. Bursa absent. Spicules paired, almost straight, slender, 12 μ long. Tail regularly tapering to end in a conoid-rounded terminus.

Holotype: Female collected on 3rd January, 1957; slide no. PN/N/1-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/N/1-002; other data same as for holotype.

Paratypes: 14 females and 4 males; other data same as for holotype.

Type host: Roots of Zea mays L. (maize).

Type locality: Aligarh (U. P.), India.

Discussion: In the absence of a valvular median oesophageal bulb, Nuditylenchus belongs to Neotylenchidae Thorne, 1949. It can further be accommodated in the Neotylenchinae Thorne, 1941 of the family Neotylenchidae by the cephalic frame-work being octagonal. From all the existing genera

of this sub-family, Nuditylenchus is distinctive because of the absence of a bursa in male. It is distinguished from Hexatylus Goodey, 1926, and Neotylenchus Steiner, 1931, by having the oesophageal glands lying free in body cavity and extending back over anterior end of intestine. In the structure of oesophagus Nuditylenchus is close to Deladenus Thorne, 1941, from which it is distinguished, besides the absence of a bursa in male, by the position of the vulva at more than 10 per cent of the body from posterior end.

Sub-family Paurodontinae Thorne, 1941

Diagnosis: Neotylenchidae: Lip region flat, traversed by striae. Labial frame-work sclerotized, hexa-radiate. Spear small, weak, with three basal knobs. Basal oesophageal bulb possessing a stem-like projection, extending into intestine. Intestine sometimes enveloping part or even all of basal oesophageal bulb. Vulva posteriorly located. Gonads monodelphic, prodelphic. Testis single, outstretched. Spicula and gubernaculum typically tylenchoid. Bursa not enveloping entire tail. Tails similar in both sexes, elongate, tapering.

Type genus: Paurodontus Thorne, 1941

Key to genera of Paurodontinae

1. Spear knobs symmetrical ..... Paurodontus Thorne, 1941
   Spear knobs asymmetrical ..... Stictylus Thorne, 1941

Genus Paurodontus Thorne, 1941

Diagnosis: Paurodontinae: With characters of the sub-family as given above. Lateral fields with 4-6 incisures. Deirids and phasmids sometimes quite difficult to see. Basal knobs of the spear symmetrical or nearly so. Tails elongated; acute or sub-acute. Bursa not enveloping more than two-thirds of the tail.

Type species: Paurodontus gracilis Thorne, 1941

Key to species of Paurodontus

1. Length of body about 0.7 mm. 2
   Length of body about 0.4 mm. 3
2. Basal oesophageal bulb enclosed in a chamber formed by the extended walls of the intestine .....
   ..... gracilis Thorne, 1941
   Basal oesophageal bulb not enclosed in a chamber ....
   ..... similis n. sp.
3. Terminus sub-acute ..... densus Thorne, 1941
   Terminus acute 4
4. Head about half as wide as neck base ... apiticus Thorne, 1941
   Head almost as wide as neck base ..... niger Thorne, 1941

The genus Paurodontus is being reported for the first time from Asia. The worms described here as P. similis n. sp. were collected by the author around roots of Brassica oleracea L. at Aligarh (U. P.). When freshly screened out of soil into water, the worms showed active movements of their bodies resembling those of free-living, soil inhabiting forms. The worms appeared to be similar to P. gracilis Thorne, 1941, but closer examination revealed that they represented a hitherto undescribed species.

Paurodontus similis n. sp.

(Plate 23, Fig. A-E)

Measurements: 5 females: Length = 0.68-0.76 mm.; a = 32-40; b = 6.3-7.5; c = 9.5-10.5; V = 79-83.5%.

4 males: Length = 0.55-0.65 mm.; a = 34-36; b = 5-6.3; c = 8.7-9.6; T = 45-50%.

Female (Holotype): Length = 0.68 mm.; a = 40; b = 7.2; c = 10.2; V = $^{41-79.6-3.5}$%.

Body long and slender, tapering anteriorly from level of base of oesophagus to lip region which is three-sevenths of body width at neck base; and posteriorly, behind region of vulva to an elongate tail. Striae averaging 1.3 μ apart on middle of body, completely interrupted by lateral fields marked by 4 incisures. Deirids located at level of excretory pore. Phasmids situated slightly more than one anal body diameter behind anus. Lip region low, flattened anteriorly, marked by 3 striae, 7.5 μ wide by 3 μ high, continuous with body contour.

PLATE 23

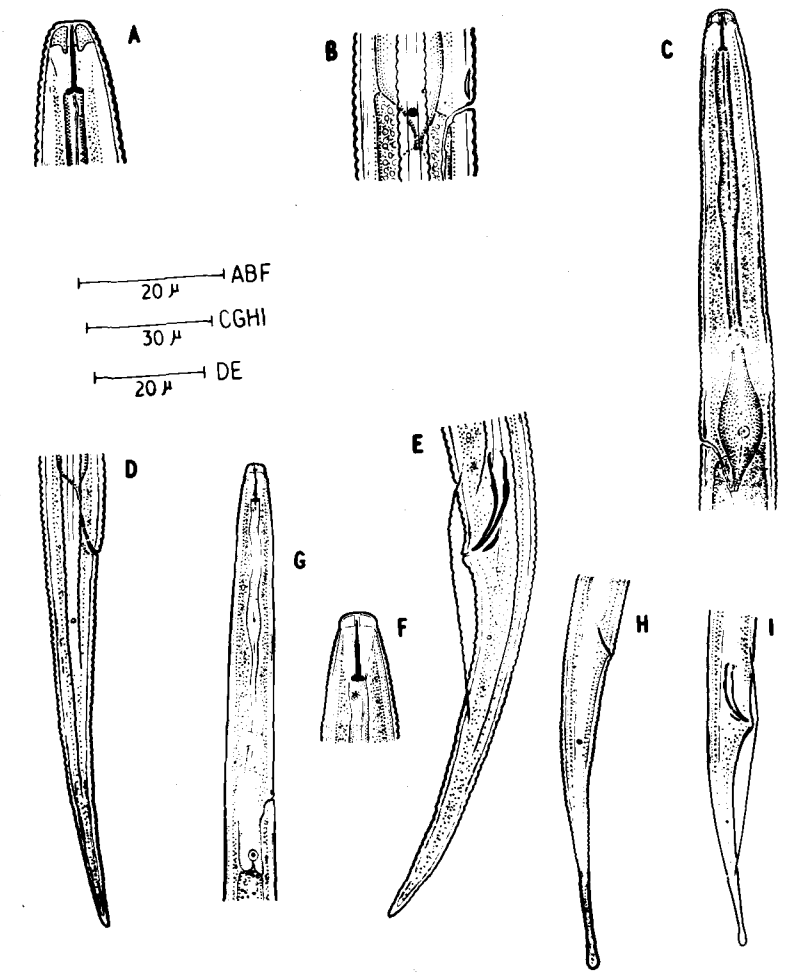


Plate 23. Figures A-E, Paurodontus similis. A. Head end of female; B. Oesophageal base and deirid in female; C. Oesophageal region of female; D. Female tail; E. Male tail; F-I, Nothotylenchus clavicaudatus. F. Head end of female; G. Oesophageal region of female; H. Female tail; I. Male ta

Labial frame-work moderately sclerotized, haxa-radiate; its inner margins extending from basal plate one body annule. Spear 9.5 μ long, divisible into two equal halves. Basal knobs of spear rounded, 2.5 μ across. Orifice of dorsal oesophageal gland close to spear base. Corpus a cylindrical tube, with a weakly developed basal swelling. Isthmus long, crossed by nerve ring near its posterior end. Basal oesophageal bulb spindle-shaped, with three gland nuclei and a valvular stem-like projection at base. The latter extending into intestine. Excretory duct distinct, opening at base of oesophagus through a strongly sclerotized pore. Hemizonid three body annules long, situated just anterior to excretory pore.

Ovary single, outstretched; oöcytes in single file. Posterior uterine branch about one-and-a-half times the vulvar body width. Vagina about one-third of body width long, opening outside through a transverse vulva. Vulva-anus distance greater than tail length. Tail regularly tapering to a sub-acute, rounded terminus, 66 μ in length, less than seven anal body diameters long.

Male (Allotype): Length = 0.65 mm.; a = 35.7; b = 5.8; c = 9.6; T = 50%.

Body essentially similar to that of female. Testis single, outstretched; spermatocytes serially arranged. Bursa distinctly crenate, about three anal body diameters long, enveloping about one-third of tail. Spicula typically tylenchoid, 19 μ long. Gubernaculum simple, trough-shaped, 6 μ in length. Tail regularly tapering and slightly ventrally arcuate, ending

in a sub-acute, rounded terminus.

Holotype: Female collected on 3rd. March, 1957; slide no. PN/N/2-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/N/2-002; other data same as for holotype.

Paratypes: 5 females and 3 males; other data same as for holotype.

Type host: Collected from soil around roots of Brassica oleracea L. (Cabbage).

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Paurodontus with the above measurements and general description. It is distinguished by its elongate, slender body; presence of three striae on head; distinct deirids at level of excretory pore; position of vulva at 79-83.5 per cent of the body from anterior end; presence of a post-uterine branch; bursa enveloping one-third of male tail; and tails of both sexes being elongate, sub-acute, with rounded terminus, measuring less than seven anal body diameters long.

P. similis n. sp. is close to P. gracilis Thorne, 1941, from which it is easily distinguished by the absence of the characteristic chamber surrounding the basal oesophageal bulb, more posteriorly located vulva (vulva at 76 per cent of body length in P. gracilis), a shorter tail ending in a sub-acute-rounded terminus, and bursa enveloping about one-third of the male tail.

Sub-family Nothotylenchinae Thorne, 1941

Diagnosis: Neotylenchidae: Body slender, eel-like. Lip region with hexa-radiate, sclerotized labial frame-work. Corpus of oesophagus cylindroid, sometimes bearing fusiform basal swelling. Basal oesophageal bulb set off from the intestine, without a posterior extension. Gonads prodelphic, outstretched. Rudimentary post-uterine branch present. Spicula and gubernaculum tylenchoid. Bursa present.

Type genus: Nothotylenchus Thorne, 1941

Key to genera of Nothotylenchinae

1. Oöcytes arranged about a rachis... Nothanguina Whitehead, 1959

   Oöcytes not arranged about a rachis 2

2. Cuticle abnormally thick and deeply striated ... . Thada Thorne, 1941

   Cuticle not abnormally thick, finely striated 3

3. Spear with flange-like basal knobs..... Boleodorus Thorne, 1941

   Spear without flange-like basal knobs 4

4. Bursa ad-anal ..... Nothotylenchus Thorne, 1941

   Bursa terminal ..... Anguillonema Fuchs, 1938

Genus Nothotylenchus Thorne, 1941

Diagnosis: Nothotylenchinae: Cuticle marked by fine, transverse striae. Lateral fields with 4-6 incisures. Hexaradiate, slightly sclerotized labial frame-work supporing a smoothly rounded low lip region which is continuous with body contour. Spear short, with rounded basal knobs. Corpus of oesophagus a cylindrical tube, with or without a fusiform, valveless proximal bulb. Distance from anterior end of body to end of corpus considerably smaller than that from the latter to base of oesophagus. Posterior oesophageal bulb set off from intestine, sometimes lobed. Female gonad single, prodelphic. Rudimentary post-uterine branch present. Testis single, outstretched. Spicula and gubernaculum tylenchoid. Bursa enveloping about half of tail or more. Tails in both sexes elongate, slightly arcuate ventrally, tapering to a variable terminus.

Type species: Nothotylenchus acris Thorne, 1941

Key to species of Nothotylenchus

1. Basal oesophageal bulb elongate, cylindrical .....
   ..... cylindricollis Thorne, 1941
   Basal oesophageal bulb tapering 2
2. Tail elongate-clavate .... clavicaudatus n. sp.
   Tail elongate-conoid 3

3. 4 incisures in lateral fields 4

   6 incisures in lateral fields 6

4. Tail terminus acute 5

   Tail terminus rounded ..... loksai Andrássy, 1959

5. Corpus with ovoid valve-like structure .....

   ..... drymocolus Rühm, 1956

   Corpus without ovoid valve-like structure .....

   ..... acris Thorne, 1941

6. Post-uterine sac shorter than body width .....

   ..... affinis Thorne, 1941

   Post-uterine sac twice the body width .....

   ..... buckleyi Das, 1960

Other species: N. thornei Andrássy, 1958

N. exiguus Andrássy, 1958

Nothotylenchus clavicaudatus n. sp.

(Plate 23, Fig. F-I)

Measurements: 1 female: Length = 0.58 mm.; a = 34; b = 5.5; c = 7.8; V = $^{25.7-}_{74.3}{}^{-3}$%.

1 male: Length = 0.55 mm.; a = 42; b = 5.8; c = 10.8; T = 43%.

Female (Holotype): Body striae 1 µ apart on mid-body. Lateral fields with 6 incisures. Lip region smoothly rounded, flattened anteriorly. Cephalic frame-work hexa-radiate, lightly sclerotized. Spear 8 µ long, with rounded basal knobs. Orifice of dorsal oesophageal gland located close to spear base. A spindle-shaped swelling devoid of valvular apparatus present at base of corpus. Isthmus elongate, tubular, crossed by nerve ring near its middle. Excretory pore located slightly

forward to level of distal end of basal oesophageal bulb. Hemizonid 3 body annules long, situated just anterior to excretory pore. Basal oesophageal bulb sac-like, completely set off from intestine. Oesophago-intestinal cells form a small cardia projecting into lumen of anterior end of intestine.

Vulva a transverse slit. Post-uterine branch a little more than one vulvar body diameter long. Uterus highly muscular. Ovary outstretched, made up of a single row of developing oöcytes. Rectum short, opening outside through a conspicuous anus. Tail elongate, clavate, slightly ventrally arcuate. Phasmids about two anal body widths behind anus.

Male (Allotype): Similar to female. Testis single, outstretched, spermatocytes arranged in single file. Spicules paired, similar, ventrally arcuate and cephalated, 15 µ in length. Gubernaculum simple, trough-shaped, 4 µ long. Bursa crenate, springing from a level slightly anterior to head of spicules and ending at middle of tail. Tail elongated, distinctly clavate.

Holotype: Female collected on 13th September, 1956; slide no. PN/N/3-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/N/3-002; other data same as for holotype.

Type host: Oryza sativa L. (rice plants)

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Nothotylenchus with the above general description and measurements. It is distinguished

from all the known species of the genus by its elongated, clavate tail. It is closely related to N. affinis Thorne, 1941, but can easily be differentiated from it because of the clavate tail and a longer post-uterine branch (posterior uterine branch shorter than body width in N. affinis).

Genus Boleodorus Thorne, 1941

Diagnosis: Nothotylenchinae: Labial frame-work hexaradiate, sclerotized. Lip region conically elevated. Spear of known species 12 μ long, with three flange-like basal knobs. Dorsal oesophageal gland opening close to base of spear. Corpus of oesophagus slightly swollen at its base. Basal oesophageal bulb pyriform, not lobed, set off from intestine. Cardia prominent. Vulva a posteriorly located transverse slit. Ovary single, prodelphic, outstretched. Post-uterine branch present. Spicula and gubernaculum typically tylenchoid. Bursa weak, about twice as long as anal body diameter, not enveloping entire tail. Tails of both sexes similar, elongate, tapering.

Type species: Boleodorus thylactus Thorne, 1941

Key to species of Boleodorus

1. Tail clavate ..... clavicaudatus Thorne, 1941
   Tail not clavate 2

2. Female tail hooked ..... thylactus Thorne, 1941

Female tail not hooked ..... citri n. sp.

Boleodorus citri n. sp.

(Plate 23, Fig. J-L)

Measurements: 6 females: Length = 0.65-0.76 mm.; a = 30-38; b = 5.8-6.9; c = 8-8.8; V = 73-74%; spear = 11-12 μ.

2 males: Length = 0.61-0.63 mm.; a = 38-41; b = 6.2-6.3; c = 7.1-7.5; T = 28-30%.

Female (Holotype): Length = 0.69 mm.;a = 33; b = 6.8; c = 8.2; V = 41-73%.

Body assuming a slightly ventrally arcuate position on death. Striae 1.1 μ apart. Lateral fields with 4 equally spaced incisures, about one-fourth as wide as body. Head conically elevated, marked by three faint transverse striae. Labial frame-work lightly sclerotized. Spear 12 μ long, with anterior tapering portion measuring 5 μ in length. Basal knobs of spear somewhat flange-like. Orifice of dorsal oesophageal gland 2 μ posterior to spear base. Corpus cylindrical, with a valveless, bulbar swelling at its base containing outlets of sub-median oesophageal glands. Distance from anterior end of body to base of corpus greater than that from latter to oesophageal base. Nerve ring enveloping isthmus slightly behind its middle. Hemizonid 3 body annules long, located 1 body annule anterior to excretory pore, near distal end of basal

oesophageal bulb. Latter pyriform, set off from intestine, containing 3 gland nuclei. Cardia large, hemispheroidal.

Ovary single, outstretched, with 17 oöcytes arranged in single file. Oviduct long. Spermatheca large, rounded. Post-uterine branch short, about one vulvar body diameter long. Vulva-anus distance only slightly greater than tail length. Rectum short, opening outside through a distinct anus. Tail regularly tapering, six-and-a-half anal body diameters in length. Caudal terminus bluntly rounded, not striated.

Male (Allotype): Length = 0.63 mm.; a = 38; b = 6.2; c = 7.1; T = 28%.

Body similar to that of female. En face view showing six, amalgamated lips surrounding a small, rounded oral opening. Lateral lips much reduced in size. Testis single, outstretched. Spicula paired, tylenchoid, 18 µ long. Gubernaculum simple, 5 µ in length. Bursa ad-anal, with crenate margins, springing from a level slightly anterior to spicula head and terminating at about one-and-a-half anal body diameters posterior to cloaca.

Holotype: Female collected on 16th August, 1957; slide no. PN/N/4-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/N/4-002; other data same as for holotype.

Paratypes: 5 females and 1 male; other data same as for holotype.

Type host: Collected around roots of Citrus sinensis(L).

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Boleodorus with the above general description and measurements. It is distinguished by its conical head bearing three faint striae, 4 incisures in lateral fields, distance from anterior end of body to base of corpus being greater than that from latter to oesophageal base, vulva located at 73 per cent of body from anterior end, vulva-anus distance being only slightly greater than tail length, presence of a rounded spermatheca, and a straight conoid tail ending in a rounded, unstriated terminus.

B. citri n. sp. is related to B. thylactus Thorne, 1941, which has been defined by Thorne as 'Boleodorus with ventrally arcuate body and hooked tail tapering uniformly to an acute terminus'. B. citri has a straight tail ending in bluntly rounded terminus. In addition, the vulva in B. citri is far posteriorly located than in B. thylactus. From B. clavicaudatus Thorne, 1941, the present species can be distinguished by the far posteriorly located vulva (vulva at 60 per cent in B. clavicaudatus), and in the vulva-anus distance being only slightly greater than the tail length which is, in the former species, more than twice the length of the tail.

Super-family Aphelenchoidea (Fuchs, 1937) Thorne, 1949

Diagnosis: Tylenchida: Orifice of dorsal oesophageal gland located in the median oesophageal bulb, just anterior to its valvular apparatus. Bursa absent except in Aphelenchidae in which the bursal wings are supported by pedunculated papillae forming ribs.

Type family: Aphelenchoididae (Fuchs, 1937) Paramonov, 1957

Family Aphelenchoididae (Fuchs, 1937) Paramonov, 1957

Diagnosis: Aphelenchoidea: Spear with or without basal knobs. Oesophageal glands free except in Paraphelenchinae where they are enclosed in basal oesophageal bulb. Spicules paired. Gubernaculum present or absent. Male without a costate bursa.

Type sub-family: Aphelenchoidinae (Fuchs, 1937) Skarbilovich, 1947.

Key to sub-families of Aphelenchoididae

1. Oesophageal glands free in body cavity, extending back over anterior end of intestine .... Aphelenchoidinae (Fuchs, 1937) Skarbilovich, 1947

   Oesophageal glands enclosed in basal oesophageal bulb ..... Paraphelenchinae Goodey, 1951

Sub-family Aphelenchoidinae (Fuchs, 1937)
Skarbilovich, 1947

Diagnosis: Aphelenchoididae: Oesophageal glands lying free in body cavity, extending back over anterior end of intestine. Basal oesophageal bulb absent.

Type genus: Aphelenchoides Fischer, 1894.

Genus Aphelenchoides Fischer, 1894

Syn: Chitinoaphelenchus Micoletzky, 1922 (sub. g.)
Schistonchus Cobb, 1927 (sub. g.)
Pathoaphelenchus (Cobb, 1927) Steiner, 1932
Seinura Fuchs, 1931

Diagnosis: Aphelenchoidinae: Lateral fields narrow, usually with 4 incisures. Median oesophageal bulb well developed. Oesophageal glands lying in body cavity, outside oesophageal tissue. Posterior region of oesophagus fused obscurely with the intestine, not distinctly set off. Ovary single, prodelphic. Post-uterine sac usually present. Tail conoid, tapering, having a terminal mucro, or filiform. Caudal alae in male lacking except in one case where terminal wings are present, replaced by paired copulatory papillae. Spicules paired, ventrally arcuate, thorn-shaped, wide in front. No gubernaculum.

Type species: Aphelenchoides parietinus (Bastian, 1865) Steiner, 1932.

Aphelenchoides parietinus (Bastian, 1865) Steiner, 1932

Syn: Goodey (1951) lists 15 species as synonyms.

This species was originally described by Bastian (1865) from yellow lichen — Xanthoria (Parmelia) parietina. Since then a large number of species related to it were described as new but later synonymized with it. Franklin (1955) has redescribed this species obtaining her specimens from the original type host and locality. Although there is great variation in its morphological characters as described by various authors, the present specimens conform very closely to those described by Franklin (1955). A study on the present specimens revealed the following formula for various measurements.

10 females: Length = 0.42-0.59 mm.; a = 24-32.2; b = 6.6-8.2; c = 12-14; V = 66-69.5%; spear = 9.5-10.5 μ.

Hosts and geographical distribution: This species is almost cosmopolitan. It is a common form usually found associated with fungi. Christie and Arndt (1937) and Schuurmans Stekhoven (1937, 1939) report this species from diseased plant materials. At Aligarh (U. P.), this species has been found associated with cabbage roots (Brassica oleracea L.) and grass, Cynodon dactylon Pers.

Aphelenchoides aligarhiensis n. sp.

(Plate 24, Fig. A-H)

Measurements: 3 females: Length = 0.5-0.7 mm.; a = 27-35; c = 16-17.5; V = 67-71%.

1 male: Length = 0.54 mm.; a = 30; b = 6.7; c = 17.5; T = 71%.

Female (Holotype): Length = 0.7 mm.; a = 35; b = 7.1; c = 17.5; V = 69%.

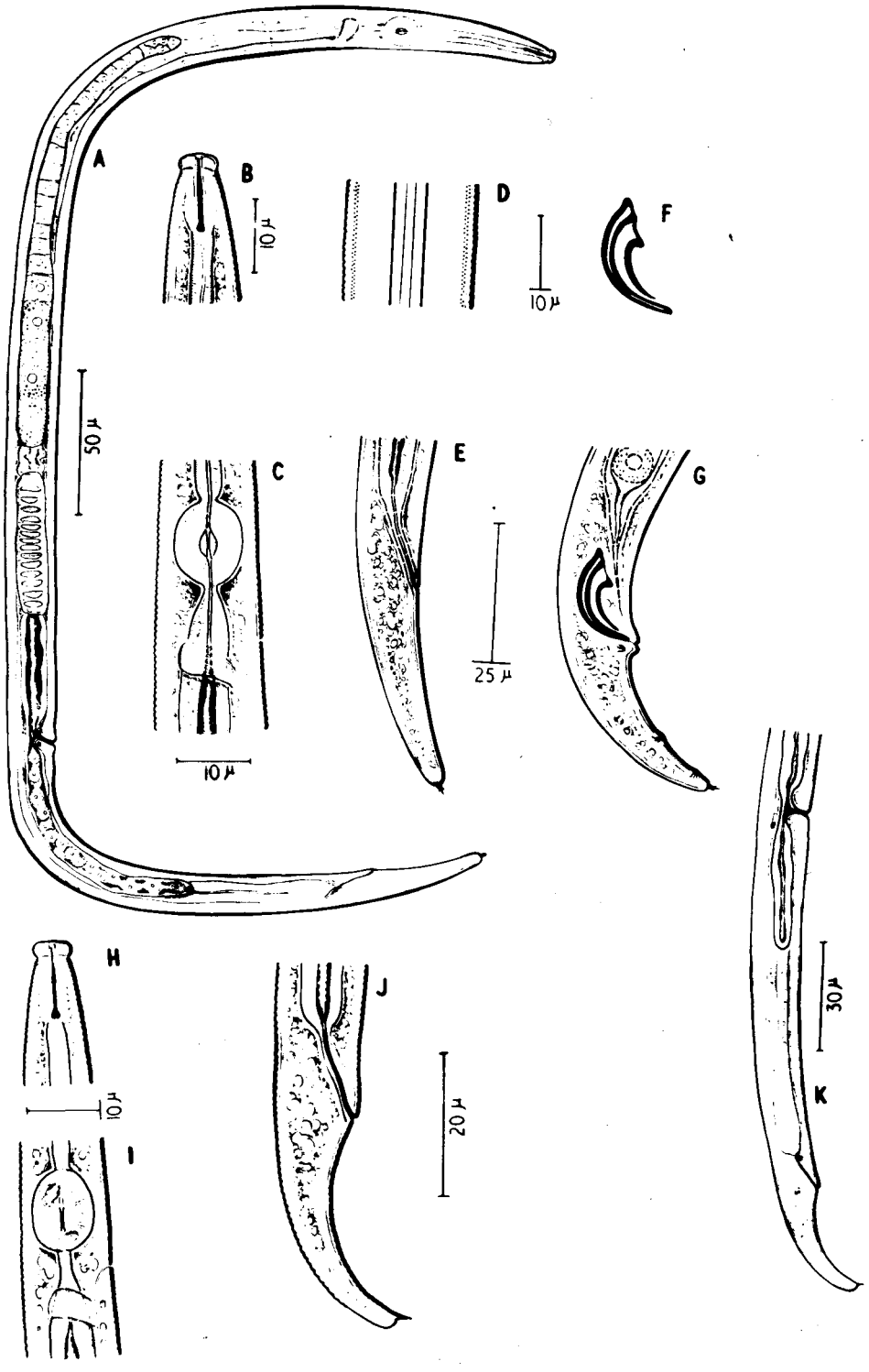
Cuticle with very fine striae, less than 1 μ apart on mid-body. Lateral fields marked by 4 distinct incisures, one-fourth as wide as body diameter. Lip region rounded, set off from body. Spear slender, 10 μ long; basal swellings of spear weakly developed, not so prominent as in A. parietinus. Oesophageal glands extending back over dorsal side of anterior end of intestine. Excretory pore located at a level slightly anterior to nerve ring. Hemizonid not seen. Ovary prodelphic, outstretched; oöcytes in single row except in a short region of multiplication. Spermatheca packed with discoid spermatozoa. Uterine sac measuring five-and-a-half times vulvar body width long, extending to more than half the vulva-anus distance, also packed with spermatozoa. Uterine egg 57 μ long by 18 μ broad.

Tail elongate-conoid, tapering to a rounded terminus armed with a tetra-mucronate spine.

Male (Allotype): Measurements same as given above.

Posterior end of body curved by about 90 degrees. Spear 10 μ long. Excretory pore at level of anterior edge of nerve ring.

PLATE 24



Testis single outstretched, reaching up to oesophageal glands. Three pairs of copulatory papillae arranged as follows: First pair ad-anal, second posterior to middle of tail, and third near caudal end. Spicula paired, ventrally arcuate, thorn-shaped, 20 μ long; ventral piece bearing at its proximal end a ventrally directed, rounded process. Caudal terminus armed with a tetra-mucronate spine.

Holotype: Female collected on 27th November; slide no. PN/A/1-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male collected on 15th December, 1957; slide no. PN/A/1-002; other data same as for holotype.

Type host: Citrus limon (L.) Burm.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Aphelenchoides with the above measurements and general description, distinctive because of fine transverse striae, four incisures in lateral fields, a slightly expanded lip region, 10 μ long buccal spear, moderately developed basal knobs of spear, excretory pore being located slightly anterior to nerve ring, position of vulva at 67-71%, a tetra-mucronate spine on tail terminus in both sexes, and size and shape of the spicula in male.

This species is related to A. besseyi Christie, 1942, A. coffeae (Zimmermann, 1898), A. ritzema-bosi (Schwartz, 1912) Steiner, 1932, A. sacchari Hooper, 1958, A. nonveilleri Andrássy, 1959, and A. asterocaudatus Das, 1960. From A. besseyi it differs in having a longer posterior uterine sac

packed with spermatozoa, a longer ovary with oöcytes in tandem, and its occurrence in soil around roots. (The author had an opportunity of studying specimens of A. besseyi obtained from rice ears kindly sent by Dr. Timm from East Pakistan). It is distinctive from A. coffeae because of a longer ovary with greater number of oöcytes, a longer post-uterine sac, and presence of males. A. ritzema-bosi differs from it in having a longer body and excretory pore located posterior to nerve ring. From A. sacchari it differs in having 4 incisures in lateral fields as compared to 3 for the former. It can be distinguished from A. nonveilleri in having a longer uterine sac, slightly swollen basal knobs of spear and the shape of the tail mucro. It can easily be distinguished from A. asterocaudatus in the absence of well developed basal knobs of the spear and presence of 4 incisures in lateral fields as compared to only 2 for the latter species. Moreover, the uterine sac in A. aligarhensis is much longer than that of A. asterocaudatus.

Sub-family Paraphelenchinae Goodey, 1951

Diagnosis: Aphelenchoidinae: Oesophageal glands enclosed in a basal oesophageal bulb.

Type genus: Paraphelenchus (Micoletzky, 1922) Micoletzky, 1925.

Key to genera of Paraphelenchinae

1. Basal oesophageal bulb set off from intestine by a constriction ..... Paraphelenchus (Micoletzky, 1922) Micoletzky, 1925

   Basal oesophageal bulb rather amalgamated with the intestine, not distinctly set off.... Metaphelenchus Steiner, 1943

Genus Paraphelenchus (Micoletzky, 1922) Micoletzky, 1925

Diagnosis: Paraphelenchinae: Lateral fields with variable number of incisures. Basal oesophageal bulb set off from intestine by a constriction. Post-uterine sac present. Tail short, tapering to a rounded terminus which may or may not be provided with a mucro. Bursa replaced by copulatory papillae. Gubernaculum present. Spicula slender, arcuate, not thorn-shaped as in Aphelenchoides.

Type species: Paraphelenchus pseudoparietinus (Micoletzky, 1922) Micoletzky, 1925.

Key to species of Paraphelenchus

1. Adult female with a terminal caudal mucro 2
   Adult female without a terminal caudal mucro
   ..... myceliophthorus Goodey, 1958
2. Tail mucro hooked, claw-like .... amblyurus Steiner, 1934
   Tail mucro not hooked..... 3
3. Lateral fields with 4 incisures ... basili Das, 1960
   Lateral fields with 8-9 incisures ..pseudoparietinus
   (Micoletzky, 1922) Micoletzky, 1925

Paraphelenchus pseudoparietinus (Micoletzky, 1922) Micoletzky, 1925

Syn: Aphelenchus (Paraphelenchus) pseudoparietinus Micoletzky, 1922

(Plate 25, Fig. F-J)

This species was described by Micoletzky in 1922 who placed it in a new sub-genus Paraphelenchus of the genus Aphelenchus. Later (1925) he raised it to generic status. Micoletzky collected his specimens around grass roots in Austria. Goodey also found this species around grass roots in St. Albans, England. The author has collected both male and female specimens around decaying sugarcane roots and from the mushroom (Agaricus sp.) at Aligarh (U. P.). The species is being reported for the first time from India. The present specimens are almost similar to those of Micoletzky, although the females are a little

more robust and the males are larger and thicker. When comparing to Goodey's description, one can notice that the females are more robust and have longer tail; while the males have smaller spicules (21-23 μ long:32 μ long). Other details are almost similar to those given by Micoletzky (1922, 1925) and Goodey (1951). The species has been illustrated and principal body measurements are given below.

6 females: Length = 0.52-0.71 mm.; a = 21-25.8; b = 4-5.5; c = 19.2-25.2; V = 75-77.3%.

5 males: Length = 0.53-0.69 mm.; a = 22-28.5; b = 4.5-5.4; c = 18-23; spicules = 21-23 μ; gubernaculum = 8-12 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis and relationship: Paraphelenchus with a conoid tail bearing a pointed mucro on ventral side of caudal terminus, 8-9 incisures in lateral fields and the arrangement of caudal papillae.

The present specimens appear to be similar to those described by Das, 1960, as P. basili n. sp. differing essentially in having 8-9 incisures in lateral fields as compared to only 4 in latter species. It differs from P. myceliophthorus Goodey, 1958, in the absence of a mucro on female tail and also in the arrangement of papillae on male tail.

Genus *Metaphelenchus* Steiner, 1943

Diagnosis: Paraphelenchinae: Basal oesophageal bulb not set off from intestine by a constriction but rather amalgamated with it, enclosing oesophageal glands. Female with 10-12 incisures in lateral fields and with a rounded caudal end. Phasmids seen at tail end, forming a papilla on either side of tail.

Key to species of Metaphelenchus

1. Vagina oblique to body axis; with a sharp constriction in lateral fields near vulva ..... *micoletzkyi* (Steiner, 1941) Steiner, 1943
   Vagina at right angles to body axis; without a sharp constriction in lateral fields near vulva 2
2. Tail end cylindrical, uniformly tapering .... *gracilis* n. sp.
   Tail end slightly clubbed ... *rhopalocercus* Steiner, 1943

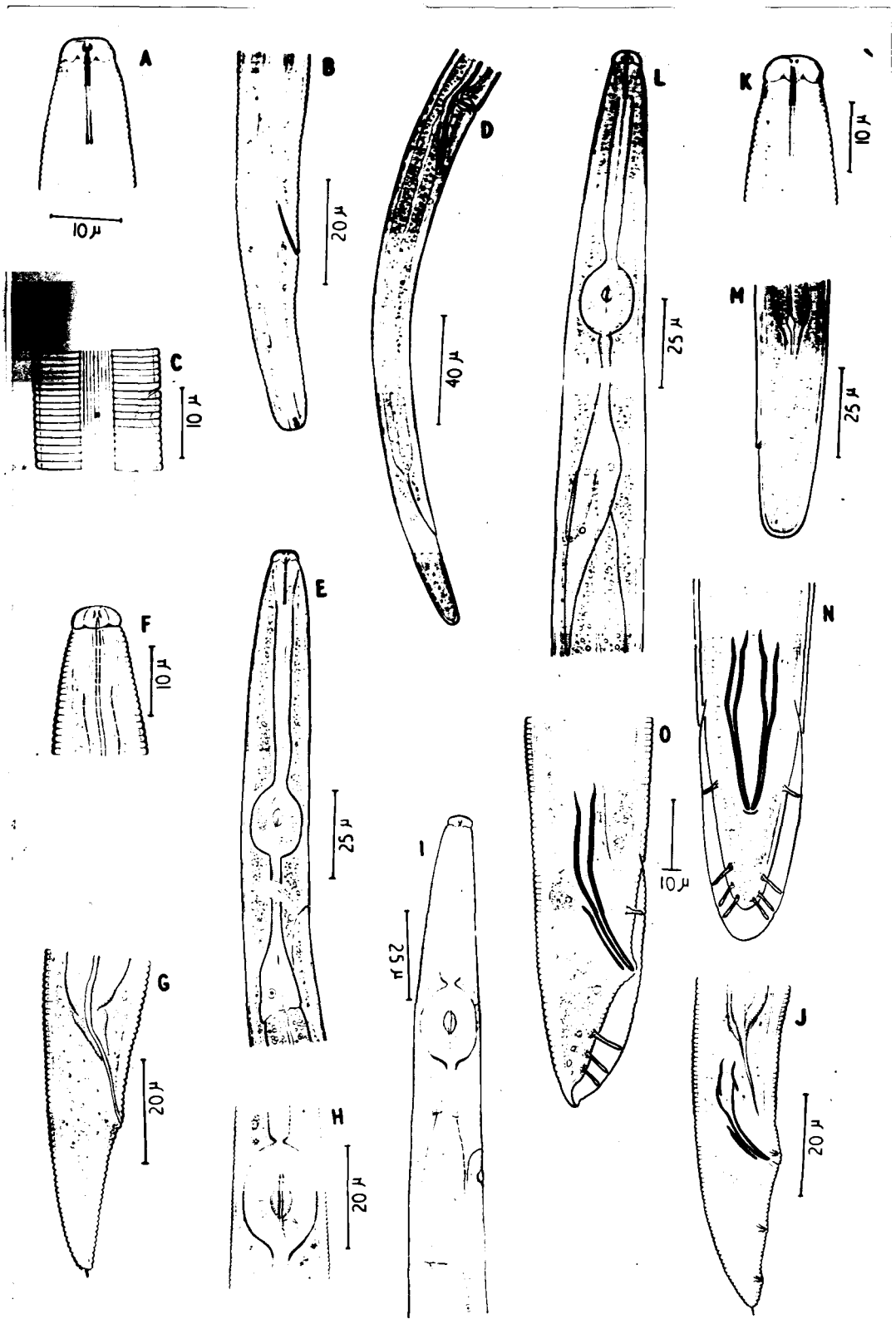
Metaphelenchus gracilis n. sp.

(Plate 25, Fig. A-E)

Measurements: 2 females: Length = 0.69-0.79 mm.; a = 34-37; b = 6-6.3; c = 23.4-25; V = 74.6-75%; spear = 14-15 µ.

Female (Holotype): Length = 0.79 mm.; a = 37; b = 6; c = 23.4; V = $^{40-}_{75}{}^{3.6}$%.

PLATE 25


A
10 µ
B
20 µ
C
10 µ
D
40 µ
L
25 µ
K
10 µ
M
25 µ
E
25 µ
F
10 µ
N
O
10 µ
I
25 µ
G
20 µ
H
20 µ
J
20 µ

Body ventrally arcuate in the form of 'C'. striae distinct, 1.2 μ apart on mid-body. Lateral fields bearing 12 equally-spaced longitudinal incisures, occupying a space about three-eighths of body width. Deirids in middle of lateral fields at region of hemizonid. Distinct phasmids seen in sub-terminal position on tail. Lip region smoothly rounded, set off from body, marked by 4 striae. Spear 15 μ long, without basal knobs. Isthmus narrower than precorpus, enveloped by nerve ring anterior to its middle, expanding posteriorly to form the basal oesophageal bulb which is imperceptibly set off from intestine. Excretory pore at level of hemizonid being only two annule anterior to it. Latter extending 4 body annules. Cardia absent.

Vulva a small, depressed, slit-like opening. Vagina leading half-way into body at right angles to body axis. Ovary single, outstretched, with oöcytes mostly arranged in double rows. Post-uterine sac about one-and-a-half vulvar body widths long. Tail elongate, almost cylindrical, about three anal body diameters long; tail terminus broadly rounded.

Male: Not found.

Holotype: Female collected on 12th August, 1958; slide no. PN/A/2-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratype: 1 female; other data same as for holotype.

Type host: Collected from soil around roots of cabbage, Brassica oleracea L.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Metaphelenchus with the above measurements and general description. It is distinctive because of the slenderness of the body, 12 incisures in lateral fields which are of uniform width near region of vulva and tail, vagina leading at right angles to body axis, presence of a post-uterine branch which measures 1½ times the vulvar body width, and a cylindrical tail which is about three anal body diameters long.

There are only two other known species of the genus Metaphelenchus viz. M. micoletzkyi (Steiner, 1941) Steiner, 1943, and M. rhopalocercus Steiner, 1943. M. gracilis n. sp. differs from the former in having a more slender body (a = 34-37:25), lateral fields being of uniform width near and behind vulvar region, vagina leading at right angles to body axis, and the presence of a post-uterine sac. From the latter species, it differs in having a more slender body, lateral fields of uniform width on tail (bulging on tail in M. rhopalocercus), and a cylindrical tail (clubbed in M. rhopalocercus).

Family Aphelenchidae Steiner, 1949

The family contains only one genus viz. Aphelenchus Bastian, 1865.

Genus Aphelenchus Bastian, 1865

Diagnosis: Oesophageal glands lying free in body cavity, extending back over anterior end of intestine. Basal oesophageal bulb absent. Lateral fields marked by 10-16 incisures. Ovary single, prodelphic. Post-uterine sac present. Tail cylindrical, with broadly rounded terminus. Male tail wrapped in by a bursa which is supported by 3-4 pairs of pedunculated papillae. Spicules paired, slender, arcuate. Gubernaculum present.

Type species: Aphelenchus avenae Bastian, 1865

Key to species of Aphelenchus

1. Lateral fields with 10-12 incisures 2
   Lateral fields with 16 incisures ... maximus Das, 1960
2. Corpus cylindrical 3
   Corpus anteriorly tapering, conoid .....
   ..... cylindricaudatus (Cobb, 1926) Steiner, 1931
3. Male with 4 pairs of caudal papillae... avenae Bastian, 1865
   Male with three pairs of caudal papillae..mirzai Das, 1960

Aphelenchus avenae Bastian, 1865

Syn: (After Goodey, 1951)

Aphelenchus agricola de Man, 1881

Aphelenchus agricola Maupas, 1900

Aphelenchoides solani Steiner, 1935

Isonchus radicicolus Cobb, 1913

(Plate 25, Fig. K-O)

The species is almost cosmopolitan in distribution. It occurs associated with decaying plant tissues. It is presumed that the worms feed on associated fungi of the decaying plant materials. Its occasional occurrence, however, in healthy plant tissues suggests its being a plant parasite. The same case led Dr. Steiner (1936) to believe that A. avenae might be feeding on plant cells.

From India the species has been reported by Das (1960) from roots of Solanum tuberosum, S. lycopersicon, Arachis hypogaea, and Hibiscus esculentus in Hyderabad (A. P.). A large number of females and few males of this species have been collected by the author from decaying onion bulbs at Aligarh. Occasional specimens have also been found around various plant roots.

The present specimens closely conform to the description of the species given by Goodey (1951). Measurements made on 20 females and 3 males are presented below.

Measurements: 20 females: Length = 0.53-0.85 mm.; a = 28-35; b = 6-8; c = 22-35; V = 75-79%.

3 males: Length = 0.55-0.62 mm.; a = 28-30; b = 7-8; c = 24-27; spicula = 27-29 μ.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Hosts and distribution: This species is widely distributed in Uttar Pradesh. At Aligarh the author has collected this nematode from the soil around roots of the following plants: Allium cepa L., Pisum sativum L., Nicotiana tabacum L., Brassica oleracea L., Musa paradisiaca L., Citrus limon (L.) Burm., C. sinensis (L.) Osbeck, Ricinus comunis L., Cyperus rotundus L., Capsicum frutescens L., Cucurbita pepo L., Saccharum officinarum L., Orobanche sp., Gossypium hirsutum L., and Carica papaya L.

Diagnosis and relationship: Aphelenchus with body assuming a straight position on death, location of vulva at 75-79% of body length from anterior end, shape of the female tail, and one pair of pre-anal and three of post-anal pedunculated papillae supporting bursa in male.

A. avenae differs from A. mirzai Das, 1960, in having 4 pairs of caudal papillae as compared to only 3 pairs in latter species. From A. maximus Das, 1960, it can be differentiated in having smaller number of incisures in lateral fields. In 1951, Goodey recongnized two other species of Aphelenchus viz. A. cylindricaudatus (Cobb, 1926) Steiner, 1931 and A. macrobolus Steiner, 1942, but added a note that these might be identical with A. avenae.

Super-family Dorylaimoidea Thorne, 1934

Diagnosis: As defined by Thorne, 1939.

Family Dorylaimidae de Man, 1876

Diagnosis: Dorylaimoidea: Amphid apertures slit-like. Lateral series of body pores present. Cuticle generally marked by fine, transverse striations. Stoma with an axial spear or a mural tooth. Oesophageal bulb cylindroid, not enveloped by a sheath of spiral muscles. Testes two. Spicules with accessory pieces. Gubernaculum absent except in Nygolaimus. Supplement consisting of ad-anal pair and a ventro-median series.

Type sub-family: Dorylaiminae Filipjev, 1918.

Sub-family Tylencholaiminae Filipjev, 1934

Diagnosis: Dorylaimidae: Spear with basal extension bearing flanges or knobs at base. Lateral series of body pores usually in double series. Oesophagus with an anterior slender portion and a posterior bulb which may be elongate or much shortened. Ovaries paired or single. Tails of both sexes similar. Spicula dorylaimoid, with accessory pieces.

Type genus: Tylencholaimus de Man, 1876.

Genus *Xiphinema* Cobb, 1913

Diagnosis: Tylencholaiminae: Spear greatly attenuated, with elongated spear extension bearing distinct basal flanges. Double guiding rings forming a tube which is usually located at base of spear. Some times, when the basal flanges of spear extension are poorly developed, the guiding ring is single and is somewhat anteriorly located. Oesophageal bulb cylindroid. Intestine may be packed with coarse, refractive granules. Pre-rectum present, sometimes obscure. Ovaries paired or single, reflexed. Supplement consisting of an ad-anal pair and a ventro-median series. Testes two, dorylaimoid.

Type species: *Xiphinema americanum* Cobb, 1913.

Key to species of Xiphinema

1. Guiding ring single, at middle of spear or more anteriorly placed 2
   Guiding rings double, at base of spear 3
2. Length = 3.5-3.89 mm. ... *brevicaudatum* Schürmans Stekhoven, 1951
   Length = 6.73-7.44 mm. ..... *citri* n. sp.
3. Ovary single 4
   Ovaries paired 7

4. Tail long, more than 4 anal body diameters .....
..... chambersi Thorne, 1939
Tail short, less than 4 anal body diameters 5
5. Tail hemispheroidal ..... ensiculiferum (Cobb, 1893) Thorne, 1939
Tail digitate 6
6. Two pairs of caudal papillae ..brasiliense Lordello, 1951
Three pairs of caudal papillae.. radicicola Goodey, 1936
7. Tail elongate (more than 3½ anal body diameters)..... 8
Tail short (less than 3½ anal body diameters) 10
8. Three to five pairs of caudal pores 9
Seven pairs of caudal pores ... insigne Loos, 1949
9. Vulva at 30.3-33.3 per cent ... indicum n. sp.
Vulva at 47 per cent ..... hallei Luc, 1958
10. Tail hemispheroidal or digitate 11
Tail conoid 18
11. Tail hemispheroidal 12
Tail digitate 13
12. Length = 0.8 mm. ..... obtusum Thorne, 1939
Length = 3 mm. ..... yapoense Luc, 1958
13. Head swollen, set off by a constriction; lips not amalgamated .. mamillatum Schuurmans Stekhoven & Teunissen, 1938
Head not swollen, normal; lips amalgamated 14
14. 'Z' organ in female present ...ebriense Luc, 1958
'Z' organ in female absent 15

15. Length about 4 mm. or more 16

Length less than 4 mm. 17

16. Length about 4 mm. ..... diversicaudatum (Micoletzky, 1927) Thorne, 1939

Length over 4 mm. ..... paraelongatus Altherr, 1958

17. Vulva at 49.8-52.6 per cent .... basiri n. sp.

Vulva at 38 per cent .... index Thorne and Allen, 1950

18. Length at least 8 mm. ... cylindricaudatum Schuurmans Stekhoven and Teunissen, 1938

Length less than 3 mm. 19

19. Vulva at more than 47 per cent 20

Vulva at less than 47 per cent 21

20. a = 56-75; vulva at 56-61.3 per cent .. opisthohysterum n. sp.

a = less than 50; vulva at about 54 per cent .....

..... americanum Cobb, 1913

21. Anterior ovary reduced .. krugi Lordello, 1955

Anterior ovary normal 22

22. Head end truncated ..... truncatum Thorne, 1939

Head end rounded 23

23. Two to three pairs of caudal papillae 24

More than three pairs of caudal papillae 26

24. Two pairs of caudal papillae 25

Three pairs of caudal papillae.. pratense Loos, 1949

25. a = 50-55; body with ventral pores ..... setariae Luc, 1958

a = 70; body without ventral pores ..parasetariae Luc, 1958

26. Four pairs of caudal papillae ... campinense Lordello, 1951

    More than four pairs of caudal papillae 27

27. Vulva at 40-42 per cent ..... elongatum Schuurmans Stekhoven and Teunissen, 1938

    Vulva at 43-47 per cent ..... italiae Meyl, 1953

It is for the first time that the so-called dagger nematodes, Xiphinema spp. are described from India. In all, seven species of this genus, of which four are new, are described below. This includes the description of two forms whose present position is still uncertain because they share some of the diagnostic characters of the genus Longidorus Micoletzky, 1922.

Xiphinema brevicaudatum Schuurmans Stekhoven, 1951

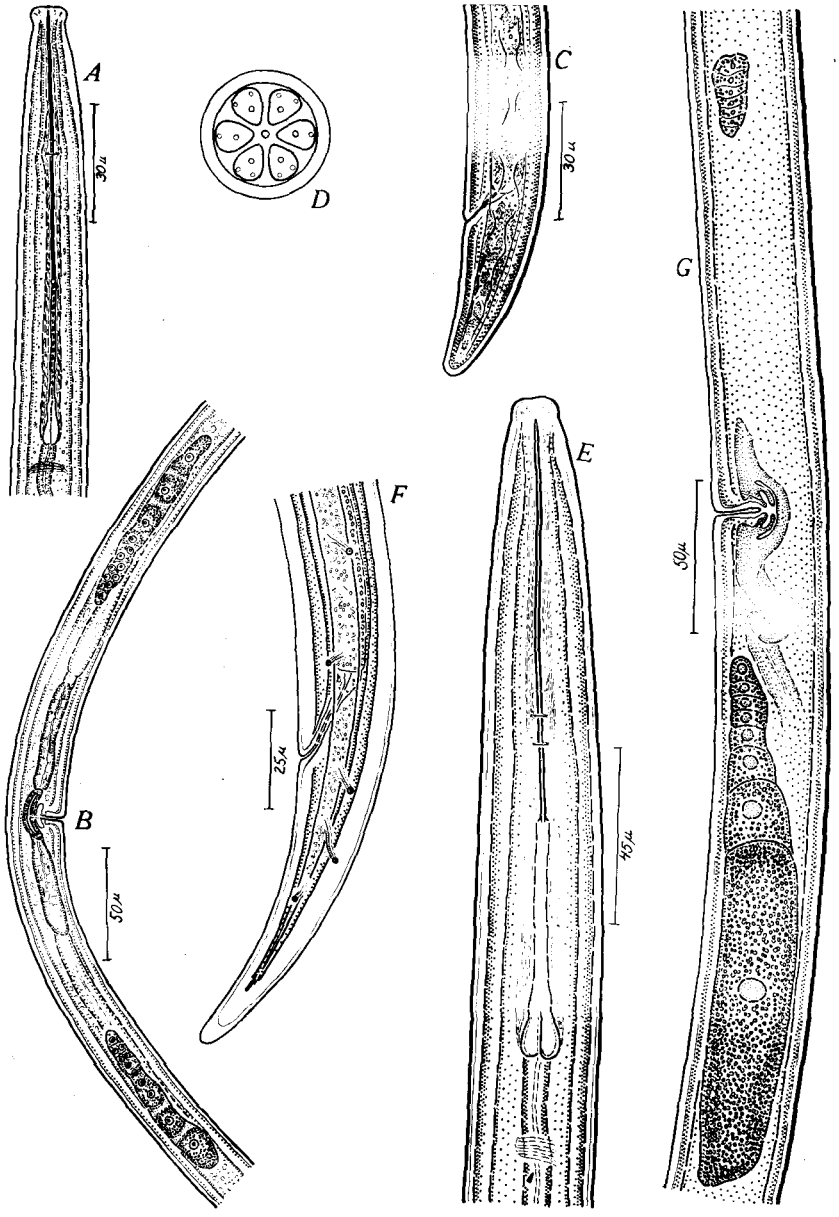
(Plate 26, Fig. A-D)

Measurements: 10 females: Length = 3.5-3.89 mm.; a = 125-138; b = 11.3-14.8; c = 87.5-109.4; V = $^{5.4-4.7-}$49.4-53.5$^{4.8-5.4}$%; spear = 65-68 µ; spear extension = 41-45.5 µ.

8 larvae: Length = 1.8-2.6 mm.; a = 95-112; b = 8.3-11.4; c = 51.5-68.2; spear = 49-57 µ ; spear extension = 23-42 µ.

Female (Holotype): Length = 3.55 mm.; a = 135; b = 14; c = 91; V = $^{5-}$50.1$^{-5.4}$%.

PLATE 26



~~Figure~~. A-D—*Xiphinema brevicaudatum.* A. Anterior end of female. B. Reproductive region of female. C. Posterior end of female. D. *En face* view. E-G—*Xiphinema indicum.* E. Oesophageal region of female. F. Tail end of female. G. Reproductive region of female.

Body long and slender, assuming a spiral form when the worm is killed by gradual heat, and tapering towards both the extremities. Anteriorly the neck expands and forms a knob-shaped head measuring 9.5μ in diameter. Lateral fields narrow, 2/7th as wide as body diameter at mid-region. Lateral body pores in two lines, appearing to lead into large, hypodermal pouches arranged in a serial order beneath the lateral fields. Cuticle very finely striated, appearing in two layers, thickest at the anterior end of neck and caudal terminus. Longitudinal striae also present. An en face view showing 16 labial papillae in two circlets. Amphid apertures minute, exceedingly difficult to see. Amphids large, appearing to encicle head.

Buccal spear 68 μ in length, with an extension measuring 42 μ in length. Latter bearing distinct basal flanges measuring one-fifth as wide as corresponding body diameter. Guiding ring single, situated at a distance of four labial diameters from anterior end, at about level of middle of spear. Oesophagus comprising of two parts, the anterior slender portion measuring 4.5 μ in diameter and a cylindrical posterior bulb measuring 64 μ long by 12 μ wide. Nucleus of dorsal oesophageal gland distinct. Nerve ring posterior to base of spear extension. Cardia well developed, conoid.

Vulva a slit-like aperture, situated at middle of body. Vagina, before leading into lumen of uteri, extending into two short, blunt diverticulae. Uterine chamber 25 μ long, with a prominent lumen. Uteri highly extensile, joined to their

corresponding oviducts by a small, muscular valvular apparatus. Ovaries symmetrical, reflexed; oöcytes arranged in single file except for a short region of multiplication. Anterior ovary on the left and posterior on the right side of intestine.

Intestine filled with large-sized food globules. Pre-rectum 8 per cent of the total body length. Rectum short, about one anal body diameter in length, opening outside through a conspicuous anus. Tail elongate-conoid, with a broadly rounded terminus. Caudal pores of lateral fields probably three pairs although not clearly seen.

Larvae: Body similar to that of female. Spear extension with distinct flanges at base. A second spear invariably present in anterior slender portion of oesophagus. Tail elongate-conoid.

Male: Not found.

Holotype: Female collected on 1st November, 1957; slide no. PN/D/1-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 9 females and 8 larvae; other data same as for holotype.

Host: Collected from soil around roots of sugarcane, Saccharum officinarum L.

Locality: Aligarh (U. P.), India.

Hosts and distribution: Schuurmans Stekhoven (1951) described a larval specimen collected around roots of Ageratum in Belgian Congo. The author has collected specimens of this species from soil around roots of sugarcane in Aligarh, Pilibhit, and Meerut districts of U. P.; grass, Cynodon dactylon Pers. in Aligarh, Pilibhit and Almora districts (U. P.); sunflower,

Helianthus annuus L.

Diagnosis and relationship: Xiphinema with a long slender body, with basal flanges on spear extension, and with spear guiding ring located much behind lip region. This species is distinctive because of long, attenuated body; a well set off, knob-like head; spear-guiding ring located near middle of spear; location of vulva at middle of body; and an elongate-conoid tail with obtuse terminus.

Xiphinema brevicaudatum is at once distinguished from all the known species of the genus by its knob-like head and anteriorly placed guiding ring. With these characters together with a slender body and large amphids it comes near to Longidorus elongatus (de Man) Thorne and Swanger, 1936, from which it differs in the more posteriorly located guiding ring and the presence of distinct flanges on the base of spear extension.

Xiphinema indicum n. sp.

(Plate 26, Fig. E-G)

Measurements: 15 females: Length = 1.983-2.241 mm.; a = 50.8-60.5; b = 5.5-6.8; c = 24.5-30.9; V = 30.3-33.3%; Spear = 101-106 μ; spear extension = 57-61 μ.

Larvae: Length = 0.75-1.37 mm.; a = 31-42; b = 3.4-4.2; c = 10.7-18.2; spear = 54-90 μ; spear extension = 39-51 μ.

Female (Holotype): Length = 2.19 mm.; a = 57.6; b = 6.8; c = 26.7; V = $^{6.8-}30.3^{-10.2}$%.

Body assuming a slightly ventrally arcuate position when the animal is killed by gradual heat. Lip region 11 μ wide by 5 μ high. Lateral fields three-elevenths of body width at mid-body region, bearing a double series of lateral pores. Spear 105 μ in length. Spear extension 58 μ long, bearing at its base large-sized flanges measuring 10 μ wide. Guiding rings 27 μ apart, at base of spear. A triangular, cuticularized piece resembling the apex of spear, located in the wall of anterior slender portion of oesophagus at about 25 μ behind base of spear extension. The same structure has also been found in X. americanum and X. basiri. No function has yet been assigned to it. As its position in the adult oesophagus is a constant feature it is presumed to be associated with the formation of a new spear whenever the older one is shed or lost. Nerve ring 67 μ behind base of spear extension. Oesophageal bulb 80 μ long by 19 μ wide. Cardia conoid, not well developed.

Vulva a transverse slit, one-third the corresponding body diameter in width. Uterine chamber present. Vagina extending into short, blunt diverticulae before opening into uterus. Ovaries asymmetrical, reflexed. Anterior ovary rudimentary, 28 μ in length; posterior one enormously developed, 176 μ long. In paratype too the anterior ovary is never normal.

Pre-rectum conspicuous, marked off from intestine, 17 per cent of total body length. Tail elongate, slightly arcuate, evenly tapering, measuring 82 μ in length, bearing three pairs of caudal pores as illustrated (Fig. F). Terminus of tail hemispheroidal, smoothly rounded.

Male: Unknown.

Holotype: Female collected on 19th December, 1957; slide no. PN/D/1-002; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: Hundreds of females; other data same as for holotype.

Type host: Collected from soil around roots of Grewia asiatica L.

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: In Aligarh, only the above-mentioned host has been found to be attacked by this parasite. However, specimens have also been recovered from soil samples collected around coffee roots in Ossoor Estate, Hasan District, South India. These samples were kindly sent by Dr. P. Soma Sekhar of the Coffee Research Station, Balehonnur, South India. The author has also collected this species around roots of tea bushes, Thea sp. in Dehra Dun and around roots of apricot, Prunus armeniaca L. in Almora districts of U. P.

Diagnosis and relationship: Xiphinema with the above measurements and general description. It can easily be distinguished from other species by its anteriorly placed vulva, didelphic condition of gonads, presence of a cuticularized piece in the anterior slender portion of oesophagus at anterior to its middle, a uterine chamber, an elongate tail, and three pairs of caudal pores.

X. indicum n. sp. comes closest to X. insigne Loos, 1949, but can be distinguished by having a slightly longer spear and three pairs of caudal pores as compared with seven for latter.

It also resembles X. ensiculiferum (Cobb, 1893) Thorne, 1937, and X. krugi Lordello, 1955, but can be distinguished from them by its elongate, ventrally arcuate tail.

Xiphinema americanum Cobb, 1913
(Plate 27, Fig. A-G)

Hundreds of females and larvae of this species have been collected by the author around roots of many fruit trees in U. P. One male specimen was also collected around roots of Citrus limon (L.) Burm. in March, 1957. These specimens appear to be identical with those described by Cobb (1913), Loos (1949), and Tarjan (1956). The male specimen, which is described below, is apparently smaller in size than that of Cobb (1913) and Oregon specimens of Tarjan (1956). However, it conforms very closely to the Rhode Island specimens described by Tarjan (l. c.) although there are certain differences, as for example, in the form and size of spicules and arrangement of the supplementary papillae — the characters which vary within this species as pointed out by Tarjan (l. c.).

Measurements: 15 females: Length = 1.55-1.73 mm.; a = 41.5-45.5; b = 5-6.7; c = 45.5-48.1; V = 50.5-53.6%.

1 male: Length = 1.52 mm.; a = 51.5; b = 5.7; c = 46; T = 40%

Female: As described by Loos (1949) and Tarjan (1956). In an en face view, the papillae of the outer circlet appear

PLATE 27

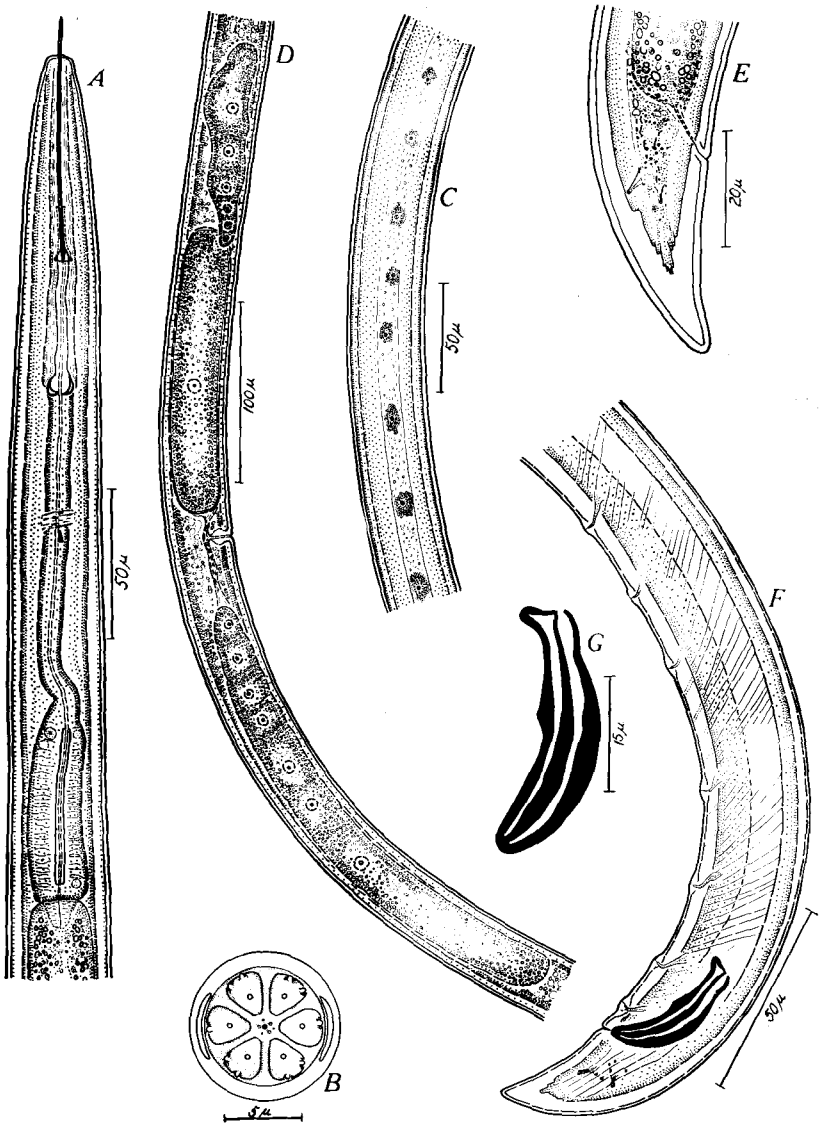


Figure 2. *Xiphinema americanum*. A. Oesophageal region of female. B. *En face* view. C. Lateral field and pores in female. D. Reproductive region of female. E. Tail end of female. F. Posterior end of male showing supplements. G. spicule.

to be arranged in two levels (vide Chitwood and Chitwood, 1950). the two lateral lips do not bear any such projections as described by Tarjan (1956). A small, triangular cuticularized structure present in the wall of the anterior slender portion of oesophagus near its middle. Uterine egg measuring 157 μ long by 27 μ wide. Tail conoid, with caudal pores as illustrated (Fig. E).

Male: Buccal spear 74 μ long; its extension measuring 47 μ in length. Testes paired; the anterior 132 μ long, outstretched, the posterior 114 μ in length, directed towards the tail. Just behind the cap-cell spermatogonia not distinctly marked out but beyond it they occur in double rows for a short distance and then come to lie in multiple rows.

Besides a pair of ad-anal papillae there are six ventromedian supplementary papillae extending within a distance equal to 4 spicula lengths from anus, spaced as illustrated (Fig. F). Copulatory musculature powerfully developed. Spicula robust, 36 μ long, sharply curved in the middle. Each re-enforced with a stout accessory piece joined posteriorly with its distal end and anteriorly with the proximal end of its ventral prong (Fig. G). Protractors of the spicula prominent. Pre-rectum indistinct. Tail dorsally convex-conoid, with two pairs of caudal pores.

Hosts and geographical distribution: X. americanum enjoys a wide range of distribution in U. S. A. Tarjan (1956) reported it as one of the most common phytonematode species of Rhode Island. Meyl (1954) reported this species from Ischia Island, Italy. Loos (1949) described only female specimens which were

collected only once from soil of a coconut estate near Kurunegala, Ceylon. The author has collected specimens from at least ten districts of U. P. Following hosts have been recorded from this state: Citrus limon (L.) Burman, C. aurantium L., C. sinensis (L.) Osbeck, Grewia asiatica L., Mangifera indica L., Malus sylvestris (L.) Mill., and Pyrus sinensis Lindl.

Xiphinema basiri n. sp.*

(Plate 28, Fig. A-H)

Measurements: 35 females: Length = 2.65-3.437 mm. (3.1 mm.); a = 57.3-71.9 (61.7); b = 6.4-8 (7.6); c = 61.8-80 (69); V = 49.8-52.6% (50.7%); spear = 111-125 μ (119); spear extension = 57-63 μ (60.6 μ).

1 male: Length = 3.027 mm.; a = 70.3; b = 6.8; c = 64.3; T = ?

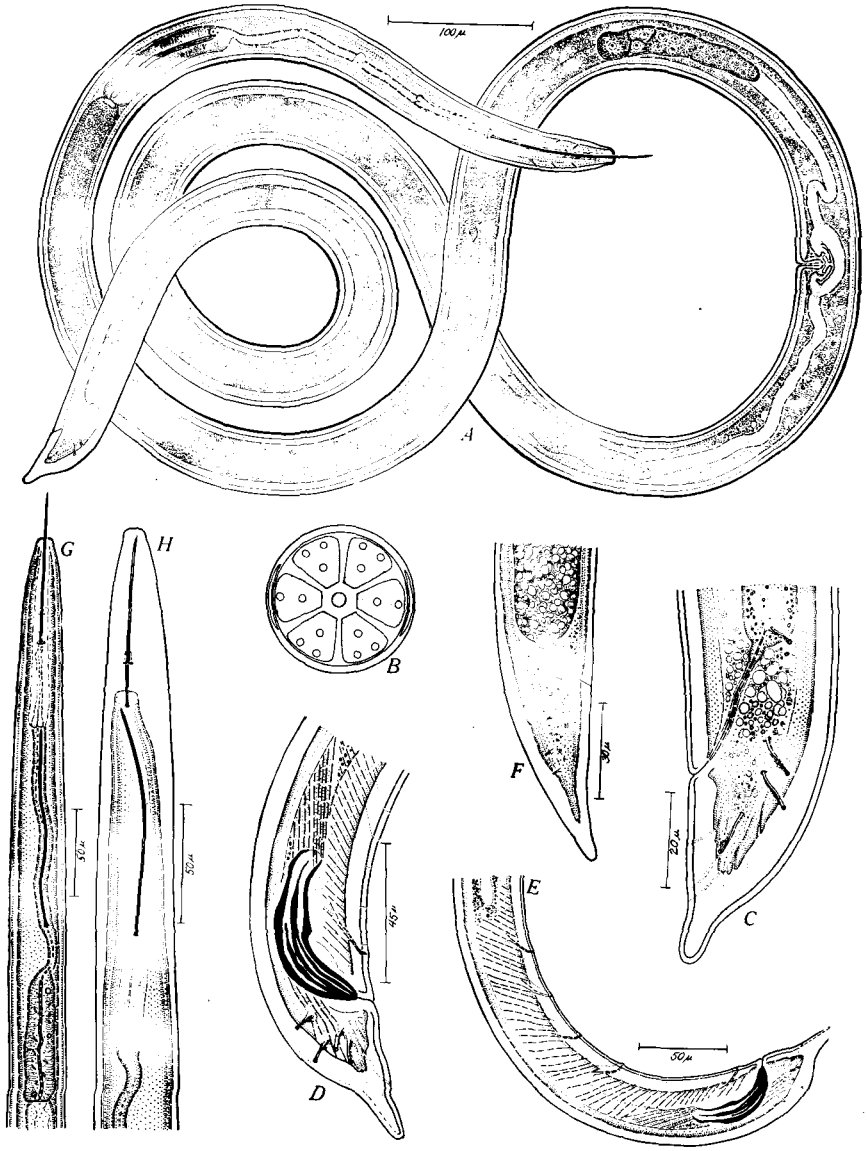
Female (Holotype): Length = 2.76 mm. a = 61.3; b = 7.1; c = 67.3; V = $^{9.2-}50.1^{12.6}$%.

Body long and cylindrical, assuming a spiral form when killed by gradual heat. Lip region only slightly marked off from body. Anterior end somewhat truncated. Amphids stirrup-shaped, three-fifths of labial diameter wide. Lateral fields

---

* Named after Dr. M. A. Basir under whose guidance this work was done.

PLATE 28



~~Figure 3.~~ *Xiphinema basiri*. A. Female. B. *En face* view. C. Tail end of female. D. Tail end of male. E. Posterior end of male showing supplements. F. Larval tail showing anlage of spicules. G. Oesophageal region of larva showing fully developed spear in oesophagus. H. Anterior end of moulting larva.

approximately one-fourth of the body diameter. Double series of lateral pores present throughout body except in anterior region where they are serially arranged. Dorsal and ventral series of pores present near anterior end of body. Spear or odontostylet 112 μ long, with a 60 μ long extension bearing powerful flanges at its base. Two guiding rings forming a 22 μ long tube located at spear base. Nerve ring 47 μ behind base of spear extension. A small, triangular cuticularized piece present in wall of anterior slender portion of oesophagus at about level of the beginning of its posterior third. Cardia large, conoid. Intestinal cells packed with granules.

Vulva a depressed, transverse slit, one-third the vulvar body diameter in width. Vagina thick-walled, leading into two short diverticulae. Powerful muscles, similar to those described by Lordello (1955) for X. krugi, attached to vulva and vagina. Uterine chamber 49 μ long, with thick muscular walls and enclosing a prominent lumen. Uteri long. Ovaries symmetrical, reflexed; oöcytes mostly arranged in double rows. One egg in a paratype female measured 178 μ long by 35 μ broad.

Pre-rectum 12.6 per cent of total body length, marked off from intestine by a lesser diameter and fewer granules in cell. Rectum slightly longer than anal body diameter, opening outside through a conspicuous anus. Tail sub-digitate, with four pairs of caudal pores and finely, radially striated cuticle.

Male (Allotype): Length = 3.027 mm.; a = 70.3; b = 6.8; c = 64.3; T = ?

Body similar to that of female. Spear 125 μ long; its

extension measuring 63 μ in length.

Supplements consist of a pair of ventro-submedian papillae and a ventro-median series of four which are regularly spaced, the first beginning at about one-and-a-half spicula length from anus. Copulatory musculature strongly developed. Spicules paired, similar, 60 μ long, cephalated, and ventrally arcuate. Each spicula strengthened with two accessory, rod-like pieces which are joined at its distal end and lie free between two prongs. Ventral piece is bifurcated at its distal half, 55 μ in length; dorsal one is solid, 33 μ long (the details of the spicules were examined while the worm was alive). Protractor and retractor muscles of spicules prominent.

Pre-rectum clearly marked off from intestine, 10.9 per cent of total body length. Tail similar to that of female, with four pairs of caudal pores.

Larvae: Length = 0.79-2.51 mm.; a = 39-57; b = 3.7-6; c = 17.5-44.8; spear = 47-107 μ.

Body becomes arcuate on death. A developing spear, larger than the functioning one, is always present in the anterior slender portion of oesophagus. Tail cylindrical, tapering to a bluntly rounded terminus.

Holotype: Female collected on 8th April, 1957; slide no. PN/D/1-003; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Male; slide no. PN/D/1-004; other data same as for holotype.

Paratypes: Hundreds of females; other data same as for holotype.

Type host: Citrus sinensis (L.) Osbeck.

Type locality: Aligarh (U. P.), India.

Habit, habitat and geographical distribution: Ecto-parasitically feeding on roots of Citrus sinensis (L.) Osbeck and Citrus reticulata Blanco. Lives in soil about roots and forms colonies of large numbers of females and larvae in various stages of development. Specimens have been collected from soil about roots of orange trees in Jhansi, Pilibhit and Meerut (U. P.) and Jabalpur (M. P.). It is presumed that this parasite is fairly well distributed in U. P.

Diagnosis and relationship: Xiphinema with the above measurements and general description. It can easily be recognized by its body length, 2.65-3.437 mm.; spear measuring 111-125 μ in length; vulva located just at the middle of body; presence of a uterine chamber; ovaries with most of oöcytes arranged in double rows; a sub-digitate tail; four ventro-median supplements and four pairs of caudal pores.

X. basiri n. sp. is most closely related to X. index Thorne and Allen, 1950, and X. diversicaudatum (Micoletzky, 1927) Thorne, 1939. It is distinguished from X. index by a slightly marked off lip region, a longer spear, a more posterior position of vulva and presence of a uterine chamber. It differs from X. diversicaudatum in having a shorter spear, more posterior position of vulva, greater width of body, greater length of neck, the smaller ratio of tail with body, presence of only 4 pairs of caudal pores on male tail as compared with 6 for diversicaudatum and a smaller length of body.

It has also some affinities with X. mammilatum Schuurmans Stekhoven and Teunissen, 1938, but can easily be distinguished

by having a shorter spear and more posteriorly located vulva.

Xiphinema citri n. sp.

(Plate 29, Fig. A-G)

Measurements: 8 females: Length = 6.73-7.45 mm.; a = 122-142; b = 12-14; c = 183-197; V = 43.3-44.8%; spear = 128-139 μ; spear extension = 70-75 μ.

Female (Holotype): Length = 6.8 mm.; a = 141; b = 13.6; c = 183; V = $^{3.8-}43.3^{-4.4}$%.

Body almost cylindrical, only slightly tapering at both ends, becoming spirally coiled when the animal is killed by gradual heat. Lip region smoothly rounded, set off from neck by a constriction, 18 μ wide by 5.5μhigh. Lateral fields one-fifth as wide as body on mid-body. A series of lateral hypodermal pouches opening outside through pores present. An en face view showing six lips bearing six papillae in inner and ten in outer circlet; papillae of outer circlet arranged in two different levels. Amphid apertures minute, difficult to see. Amphids only 7 μ wide, not encircling head completely (Fig. E).

Odontostylet 133 μ long, with 72 μ long extension bearing distinct basal flanges (Fig. F). Spear guiding ring single, located two cephalic diameters from anterior extremity. Nucleus of dorsal oesophageal gland prominent. No distinct cardia. Intestine with a large lumen at anterior end.

PLATE 29

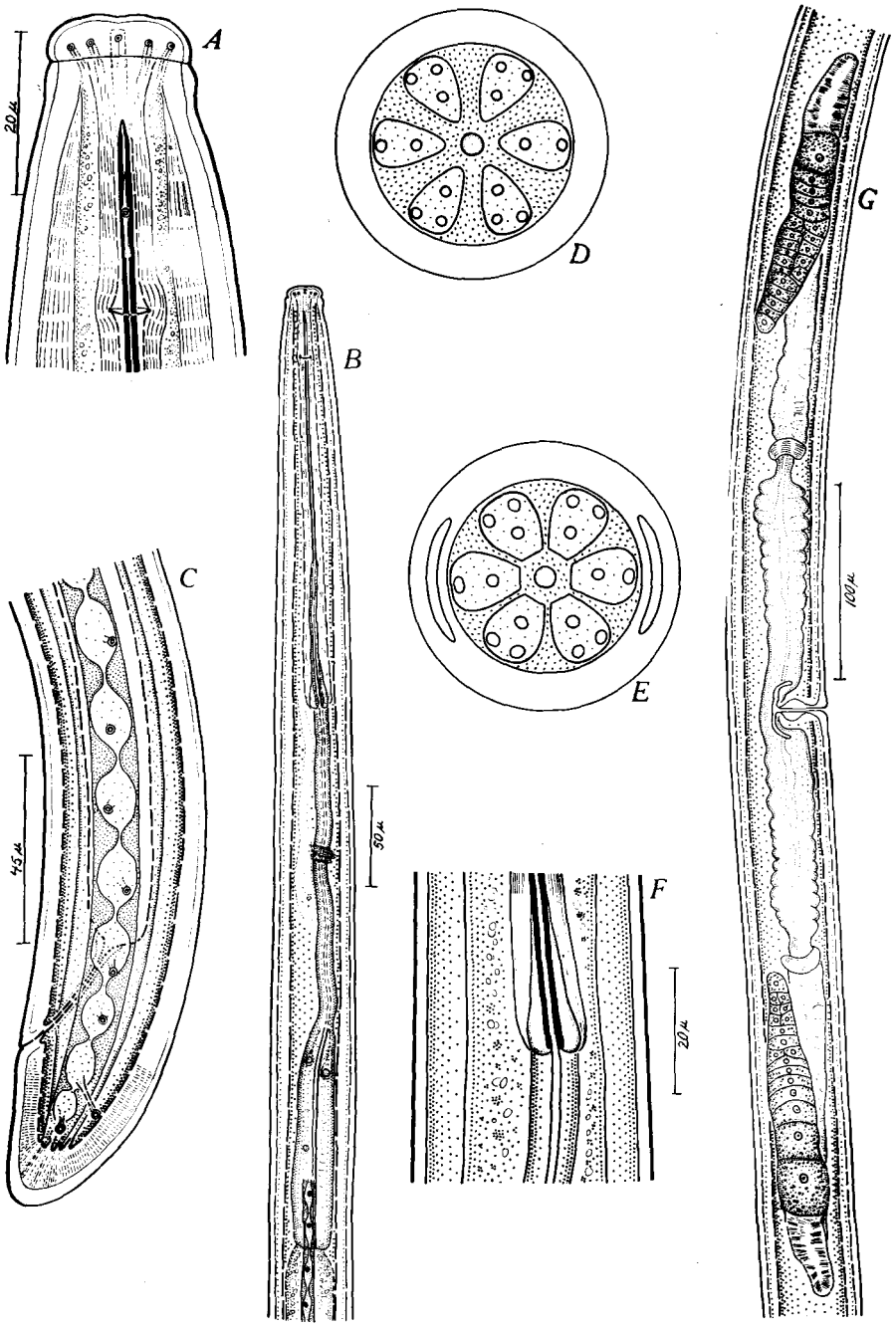


Figure. *Xiphinema citri*. A. Anterior end of female. B. Oesophageal region of female. C. Posterior end of female. D. *En face* view. E. Amphids at the base of the lip region. F. Flanged base of spear extension. G. Reproductive region of female.

Genital organs consisting of a transverse, slit-like vulva located anterior to middle of body, an extensible vagina leading nearly half-way in body into a uterine chamber with a well marked lumen, two uteri with highly extensile walls and a pair of oviducts and ovaries. Ovaries similar and reflexed.

Pre-rectum about 400 µ long. Rectum almost equal to anal body diameter, opening outside through a conspicuous anus. Tail dorsally convex-conoid, with two pairs of lateral hypodermal pouches and their corresponding pores. Caudal terminus obtuse, smoothly rounded.

Holotype: Female collected on August 7, 1957; slide no. PN/D/1-005; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 7 females and 5 larvae; other data same as for holotype.

Type host: Citrus limon (L.) Burm.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Xiphinema because of slender body, amphids not encircling the head completely and presence of flanges on spear extension. This species is distinctive because of greatly attenuated body, a well set off lip region, a long spear with its guiding ring located near its apex, position of vulva and a short, dorsally convex-conoid tail.

In its large size of the body X. citri n. sp. resembles X. cylindricaudatum Schuurmans Stekhoven and Teunissen, 1938, but can easily be distinguished by its extremely slender body, anteriorly located nerve ring, smaller length of oesophagus, more anteriorly placed vulva and a short, dorsally convex-conoid tail.

Xiphinema opisthohysterum n. sp.

(Plate 30, Fig. A-C)

Measurements: 20 females: Length = 1.62-2.1 mm.; a = 56-75; b = 6.1-7.9; c = 46-64; V = 56-61.3% (58.4%); spear = 62-72 μ; spear extension = 34-40 μ.

Female (Holotype): Length = 1.8 mm.; a = 63; b = 6.4; c = 54; V = $^{10-59}10.2$%.

Body elongate, slender, assuming an open spiral form on death. Lip region rounded, knob-like, 8.5 μ in width, set off from neck contour by a depression. En face view showing slightly raised lips bearing the usual 16 papillae. Amphids stirrup-shaped, half as wide as head, opening at base of lateral lips. Lateral fields two-fifths of body width; lateral pores not arranged in definite lines.

Buccal spear attenuated, 71 μ long; its base appearing to bear three, outwardly directed pointed projections for giving it a firm attachment to its extension. Spear extension 38 μ long, distinctly flanged at base; flanges not so prominently developed as in X. americanum, 5.5 μ across. Guiding tube located near junction of spear with its extension. Oesophageal bulb 60 μ long by 12 μ wide. Cardia poorly developed, conoid.

Vulva a transverse slit, 8 μ long, located much behind middle of body. Two sets of reproductive organs displaced in opposite directions, lying on left side of intestine. Ovaries paired, reflexed; oöcytes arranged in single file. Uterine egg in paratype 159 μ long by 26 μ broad.

Pre-rectum not discernible. Rectum a little less than

PLATE 30

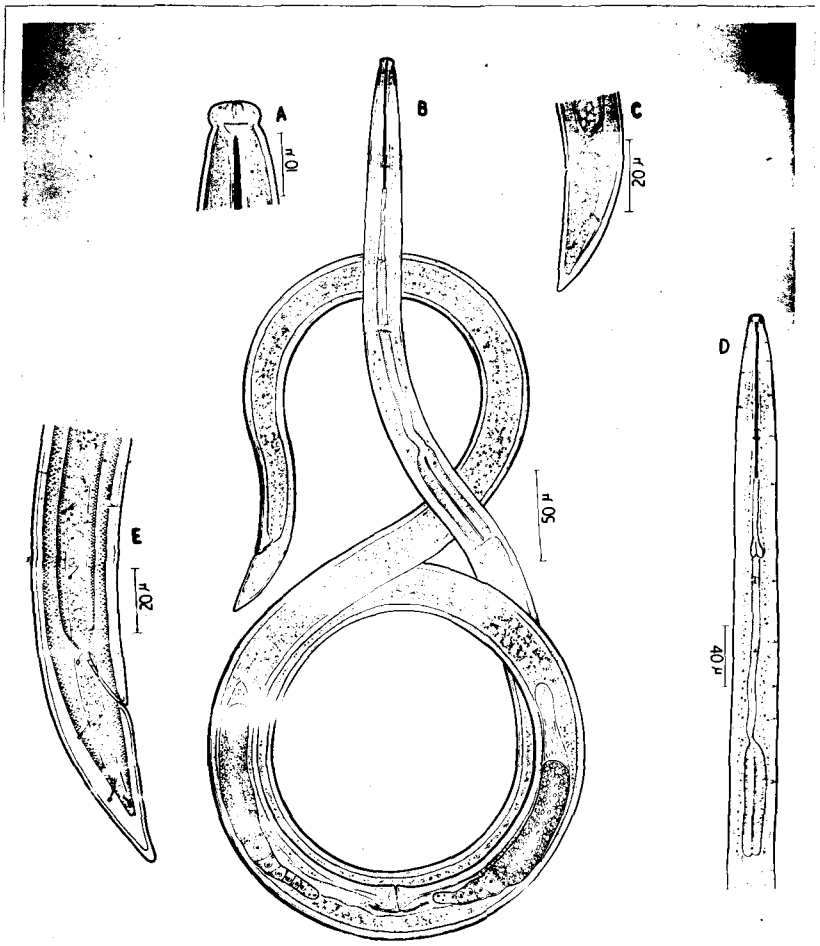


Plate 30. Figures A-C, Xiphinema opisthohysterum.

A. Head of female; B. Female; C. Female tail. D-E, X. pratense. D. Oesophageal region of female; E. Posterior end of female.

anal body diameter, opening outside through a distinct anus. Tail conoid, regularly tapering to a conoid-rounded terminus, bearing two pairs of caudal pores, measuring two-and-a-quarter times the anal body diameter in length.

Male: Not found.

Holotype: Female collected on 3rd January, 1959; slide no. PN/D/1-006; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Paratypes: 19 females; other data same as for holotype.

Type host: Aegle marmelos Correa.

Type locality: Aligarh (U. P.), India.

Hosts and geographical distribution: Specimens of this species have been collected from soil around roots of Aegle marmelos Correa and Eugenia jambolana Lamk. at Aligarh (U. P.) and around roots of A. marmelos in Karwi, Banda District (U. P.).

Diagnosis and relationship: Xiphinema with the above general description and measurements. It is distinctive because of the size of body, slightly set off lip region with raised lips, 62-72 μ long spear, position of vulva at 56-61.3 per cent of body from anterior end and a conoid tail with only two pairs of caudal pores.

X. opisthohysterum n. sp. comes closest to X. americanum Cobb, 1913, from which it can be distinguished by its more slender body, a knob-like head with slightly raised lips, a shorter buccal spear, a shorter spear extension with poorly developed basal knobs, a more posteriorly located vulva and a more conoid tail which is regularly tapering and more than two anal body diameters long. From all other known species it can easily be separated by its far posteriorly located vulva.

Xiphinema pratense Loos, 1949

(Plate 30, Fig. D-E)

This species was originally described by Loos (1949) as occurring around grass roots in Talawakelle, Ceylon. It has now been found around roots of Carissa sp. growing in hilly regions of Karwi, Banda District (U. P.). The present specimens conform closely to the description of the species given by Loos (l. c.). However, there is a slight difference in the size of the buccal spear. The total length of the spear (spear plus spear extension) as given by Loos for this species is 142-155 microns whereas, in the present specimens, it is 156-162 microns. The species is briefly re-described here to give further information about its morphological characters. Of importance is the location of a cuticularized, triangular piece in the anterior slender portion of oesophagus and a ventro-median series of body pores.

Measurements: 6 females: Length = 1.79-2.26 mm.; a = 43-55; b = 5-6; c = 38-46; V = 42-44%; spear = 100-105 µ; spear extension = 56-58 µ.

Female: Body assuming a slightly ventrally arcuate position on death. Lateral fields narrow 1/4 to 1/5 as wide as body diameter on mid-region. Lateral hypodermal pouches not discernible; their pores irregularly scattered over lateral fields. A series of ventral body pores running through almost the whole body length, beginning just behind lip region and ending about two body diameters anterior to anus. Dorsal body

pores also located near anterior and posterior extremities. Lip region rounded, slightly flattened anteriorly, set off from body by a depression. Amphid apertures half the width of head, slit-like. Buccal spear bearing three sharp projections at its base to give a firm attachment to its extension. Basal flanges of spear extension powerful. A small, triangular, cuticularized piece lying embedded in wall of anterior slender portion of oesophagus near its middle. Cardia well developed, conoid-rounded.

Vulva a depressed slit, leading into a thick-walled vagina communicating with the uterine chamber. Ovaries paired, reflexed. Tail sub-digitate, with three pairs of caudal pores.

Specimens deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Diagnosis and relationship: Xiphinema with the above general description. It is distinctive because of the body-size, arcuate position of body on death, a slightly set off lip region, length of spear and its extension, position of vulva, presence of a uterine chamber, presence of a cuticular piece in wall of anterior slender portion of oesophagus near its middle and a sub-digitate tail with three pairs of caudal pores.

X. pratense Loos, 1949, comes closely to X. setariae Luc, 1958, from which it differs in having a shorter buccal spear (total length of spear = 192-199 μ in X. setariae), a more posteriorly located vulva and presence of three pairs of caudal pores as compared to two in latter species.

Genus *Trichodorus* Cobb, 1913

This is the first report of the genus *Trichodorus* from Asia. The systematic position of this genus is doubtful. Thorne (1939) placed it in the sub-family Trichodorinae Thorne, 1935, of the family Diphtherophoridae Thorne, 1935. However, Allen (1957), who has reviewed this genus, is doubtful about the relationship of the two sub-families of Diphtherophoridae viz. Trichodorinae and Diphtherophorinae. The diagnosis of *Trichodorus*, as amended by Allen (1957), is given below.

Diagnosis: Dorylaimoidea: Pharynx with a protrusible dorsal tooth or onchiostyle which is tripartite posterior to the middle. Onchiostyle hollow only for a short distance anterior to its tripartite region. Amphid apertures distinct, elliptical. Oesophagus enlarged at base to form an elongate bulb containing five oesophageal gland nuclei. Ovaries one or two, in forms with one ovary it is outstretched and not reflexed as in other dorylaims. Males with or without bursa. Paired ad-anal papillae not present. Spicules straight to slightly curved. Gubernaculum present, slender.

Type species: *Trichodorus primitivus* (de Man, 1884) Micoletzky, 1922.

(for a key to species of *Trichodorus* *vide* Allen, 1957)

Trichodorus mirzai n. sp.[1)]

(Plate 31, Fig. A-I)

Measurements: 2 males: Length = 0.518-0.52 mm.; a = 18-19.1; b = 4.5-5.1; c =45-57.5; T = 62-63%.

3 females: Length = 0.492-0.609 mm.; a = 18.4-19.6; b = 4.6-6.3; c = sub-terminal; V = $^{15\text{-}25.6\text{-}}_{54.1\text{-}54.5}{}^{\text{-}14.6\text{-}21}$%; onchiostyle = 31-34 µ.

Male (Holotype): Length = 0.518 mm.; a = 18; b = 4.5; c = 45; T = 63%.

Body cylindrical, tapering abruptly at the ends. When killed by gradual heat the worm assumes a straight position and the cuticle swells up considerably. Lip region 7 µ wide. Amphid apertures 2.5 µ wide. Each amphid continued posteriorly into a globular pouch of the same width containing bundles of hair-like sensillar elements. Onchiostyle or spear 29 µ in length, tripartite at middle third. A guiding ring, which has been shown by Allen (1957) to be a muscular collar where the lumen of oesophagus empties into the pharynx, present slightly anterior to tripartite region of spear. Anteriorly, there are three, large ventro-median cervical papillae; the first from anterior end situated at about one labial diameter and the second one spear length behind base of onchiostyle, the third is about 10 µ posterior to second. Oesophagus with an anterior slender tubular portion and a posterior bulb containing gland nuclei. Nerve ring slightly anterior to middle of anterior portion of oesophagus. Excretory pore could not be located, possibly as in female. No

---

1) Named after Prof. M. B. Mirza.

PLATE 31

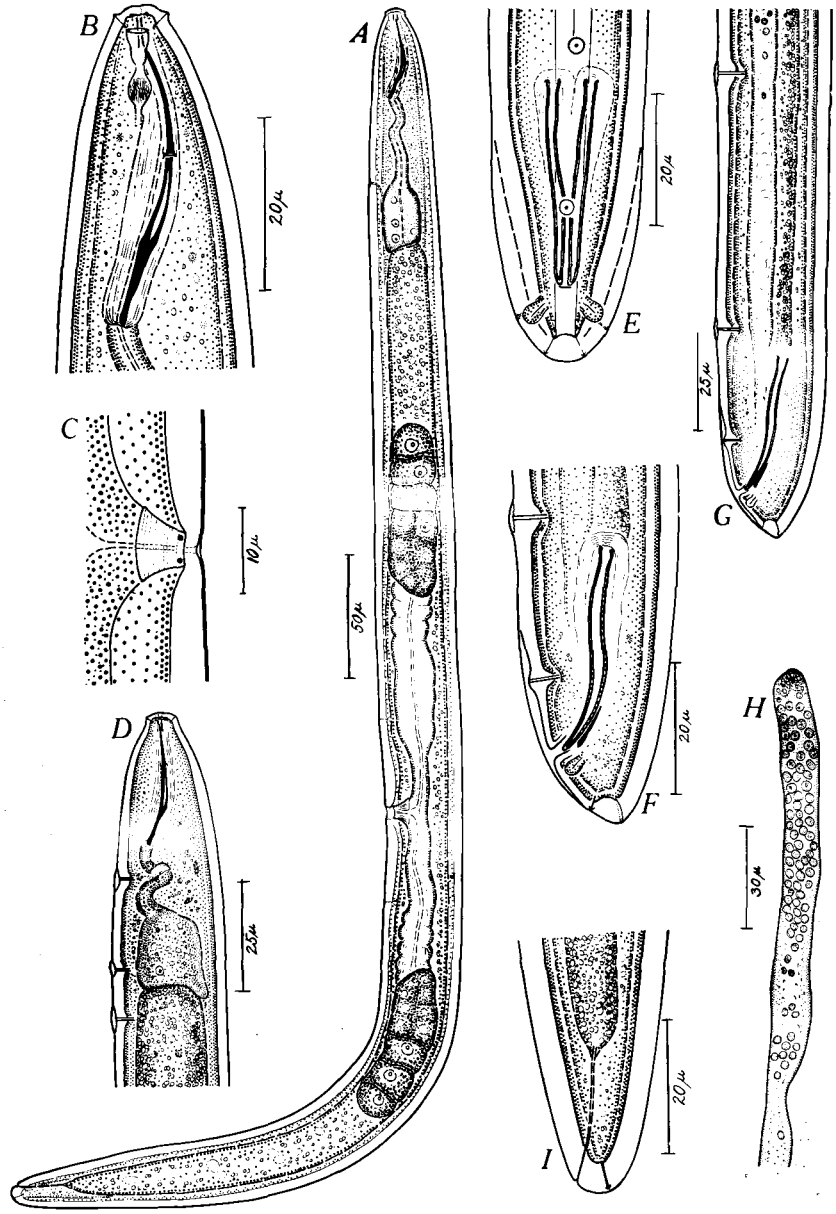


Figure 1 *Trichodorus mirzai*. A. Female. B. Anterior end of female. C. Vulva and vagina. D. Oesophageal region of male. E. Caudal end of male, ventral view. F. Caudal end of male, lateral view. G. Posterior end of male. H. Testis. I Caudal end of female.

Cardia or oesophago-intestinal valve is seen. Intestinal cells packed with food granules.

Testis single, outstretched. Details of formation of sperms as illustrated (Fig. H). Supplements consisting of three ventro-median papillae displaced as shown in Fig. G. Spicules paired, arcuate, 32.5 μ long, with faint beaded markings. Gubernaculum linear, 11 μ long, with a distal thickening.

A pair of large, pedunculated ventro-median papillae present just posterior to anal opening. Another pair of post-anal papillae located at about middle of distance from first pair of post-anal papillae to paired terminal caudal pores. A weak, not very conspicuous bursa beginning from level of middle of distance between first and second supplementary papillae and completely enveloping tail.

Female (Allotype): Length = 0.609 mm.; a = 13.4; b = 6.3; c = sub-terminal; V = $\frac{25.6-}{54.1}\frac{-20.8}{}$%.

Body similar to that of male. Spear 33 μ long. Excretory pore located at level of distal end of posterior bulbar portion of oesophagus. Ventro-median cervical papillae absent. Oesophageal bulb set off from intestine, containing about 5 gland nuclei.

Vulva a longitudinal slit-like aperture, only 2 μ long, leading into a short vagina provided with circular musculature. Cuticularized pieces surrounding vagina inconspicuous, dot-like (Fig. C). Ovaries well developed, reflexed approximately half-way back to vulva. Behind cap-cell, oögonia in double rows then coming to lie in single file.

Posterior end of body narrowing rather abruptly to a rounded terminus. Rectum long, conspicuous, opening through a distinct sub-terminal anus. Paired terminal caudal pores slightly dorsal in position.

Holotype: Male collected on 12th April, 1957; slide no. PN/D/2-001; deposited with the Zoology Museum, Aligarh Muslim University, Aligarh (U. P.), India.

Allotype: Female collected on 15th April, 1957; slide no. PN/D/2-002; other data same as for holotype.

Paratypes: 1 male and 1 female; other data same as for holotype.

Type host: Collected around roots of cabbage, Brassica oleracea L.

Type locality: Aligarh (U. P.), India.

Diagnosis and relationship: Trichodorus with the above measurements and general description. It can be recognized by its small size of body, a small onchiostyle and in male by presence and position of 3 ventro-median cervical papillae, a pair of terminal caudal pores, 3 ventro-median supplementary organs and a thick-walled bursa; in the female, by the location of excretory pore, inconspicuous pieces surrounding vagina and presence of terminal caudal pores.

T. mirzai n. sp. is closest to T. minor Colbran, 1956 (= T. christiei Allen, 1957) from which its females can be distinguished by having a well set off oesophagus and absence of paired terminal caudal pores. From the related T. nanus Allen, 1957, its female can be distinguished by the anteriorly located excretory pore and the presence of paired terminal caudal pores.

A LIST OF NEW HOST RECORDS* REPORTED IN THE TEXT

Aegle marmelos Correa ..... *Hoplolaimus tylenchiformis*; *Xiphinema opisthohysterum*.

Agaricus sp. ..... *Paraphelenchus pseudoparietinus***

Brassica oleracea L. ..... *Tylenchorhynchus rugosus*; *T. brassicae*; *Hoplolaimus tylenchiformis*; *Paurodontus similis*; *Aphelenchoides parietinus*.

Cajanus indicus Spreng ..... *Tylenchorhynchus indicus*.

Carissa sp. ..... *Tylenchorhynchus carissae*; *Hemicriconemoides cocophillus*; *Hemicycliophora indica*; *X. pratense*.

Citrus aurantium L. ..... *Basiria graminophila*.

C. limon (L.) Burm. ..... *Tylenchus* (*Filenchus*) *filiformis*; *Tylenchorhynchus indicus*; *B. graminophila*; *Hoplotylus tenuicaudatus*; *Pratylenchus grandis*; *P. musicola*; *Criconema tenuicaudatum*; *Criconemoides parvulum*; *C. citri*; *Hemicriconemoides mangiferae*; *Aphelenchoides aligarhiensis*; *X. citri*.

C. reticulata Blanco .....*Rotylenchulus reniformis*; *H. tylenchiformis*; *P. musicola*; *H. mangiferae*; *X. basiri*.

---

* The nematodes have been found associated with the roots of the plants and trees listed here.

** The worms were found in the organs of fructification of *Agaricus* sp.

C. sinensis (L.) Osbeck ... P. musicola; Boleodorus citri; X. basiri.

Coffea arabica L. ..... R. reniformis; X. indicum.

Cucurbita pepo L. ..... A. avenae.

Cynodon dactylon Pers. .... Tylenchus (Aglenchus) parvus; B. graminophila; Telotylenchus indicus; H. erythrinae; Criconemoides citri; A. parietinus; X. brevicaudatum.

Cyperus rotundus L. ..... Tylenchorhynchus elegans; A. avenae.

Eugenia jambolana Lamk. ... H. tylenchiformis; X. opisthohysterum

Grewia asiatica L. ..... R. reniformis; H. tylenchiformis; C. citri; H. mangiferae; X. indicum; X. americanum.

Grass ..... Tylenchorhynchus capitatus.

Helianthus annuus L. ..... R. reniformis; X. brevicaudatum.

Hibiscus rosa-sinensis L. ..Meloidogyne incognita.

Malus sylvestris (L.) Mill. Criconema pruni.

Mangifera indica L. ..... T. (F.) filiformis; R. reniformis; H. tylenchiformis; H. mangiferae; X. americanum.

Mentha sp. ..... Tylenchorhynchus rugosus.

Orobanche sp. ..... T. rugosus; A. avenae.

Oryza sativa L. ..... T. elegans; Nothotylenchus clavicaudatus.

Pisum sativum L. ..... T. rugosus.

Phoenix sp. ..... Paratylenchus sp.

Prunus armeniaca L. ..... Criconema pruni; C. multisquamatum; H. mangiferae; X. indicum.

P. communis Huds. ..... C. pruni.

Pyrus sinensis Lindl. ..... X. americanum.

Psidium gaujava L. ..... *Ditylenchus nanus*; *H. tylenchiformis*; *Pratylenchus brachyurus*.

Saccharum officinarum L. ... *Tylenchorhynchus indicus*; *T. elegans*; *Ditylenchus myceliophagus* (?); *Criconema brevicaudatum*; *H. mangiferae*; *Paraphelenchus pseudoparietinus*; *X. brevicaudatum*.

Solanum melongena L. ..... *H. tylenchiformis*.

S. tuberosum L. ..... *Tylenchorhynchus rugosus*.

Tamarindus indica L. .....*H. tylenchiformis*.

Thea sp. ..... *X. indicum*.

Zea mays L. ..... *Ditylenchus zeae*; *Nuditylenchus zeae*.

PART II

Nematodes attacking citrus trees in Uttar Pradesh (North India), with preliminary experimental studies on the nematode root-rot of citrus

Introduction

For the last few decades the eel-worm diseases of plants and trees have been intensively investigated and valuable results obtained. A large number of fruit trees are known to be seriously attacked by these tiny but destructive nematodes resulting in considerable loss in fruit production. Researches on nematodes attacking citrus trees are especially being carried out in the United States of America. It is both strange and regrettable that, inspite of the fact that India has a big citrus industry, these problems are still untouched. It is, perhaps, due to the fact that the eelworms are generally less than 1 millimeter long and as many kinds of them live in soil and feed ecto-parasitically on roots, they escape our notice. Moreover, the injuries caused by the nematodes are often insidious.

In early 1956, the writer in his survey of plant-parasitic nematodes of Aligarh District (U. P.) found a large number of lemon and orange trees with typical 'nematode root-rot' injuries. A close examination of such roots revealed well established colonies of a lesion nematode, Pratylenchus musicola. The lesion nematodes rank as one of the most notorious phyto-parasites.

Realizing the economic importance of the disease it was proposed to investigate into its prevalence and range of distribution. Consequently, a large number of citrus trees with disease symptoms such as general die-back of the parts above the ground, inhibited fruit production, falling down of unripe fruits, defoliation, root-injury and so on, were examined. The findings of this preliminary survey revealed a fairly wide distribution of this parasite in citrus orchards in Aligarh.

Suspecting the presence of other parasitic nematodes around citrus roots, a wide-range survey of citrus trees of Aligarh District was carried out. Later, studies were made on the distribution of the parasitic nematodes of citrus in Uttar Pradesh, host-parasite relationship and pathogenicity, egg-laying and hatching of Pratylenchus musicola* and the possible control of the nematodes attacking citrus trees.

These studies were carried out rather in a preliminary manner and in a limited period of time. It is hoped that it will bring to light the real importance of the nematodes as a possible source of danger to citrus trees and will serve as a pre-requisite to those who will further study the nematode diseases of one of the most important fruit-crops of India i. e. citrus.

---

* Pratylenchus musicola (Cobb, 1919) Filipjev, 1936, was reduced to a synonym of P. coffeae (Zimmermann, 1898) by Sher and Allen, 1953. The morphological studies conducted on the present specimens revealed that P. musicola (Cobb) is a valid species. Vide text of Part I of this work.

Reviw of literature

The actual phase of investigation on citrus nematodes dates back to the issue of circular no. 85 of the Agricultural Station, University of California, in which Thomas (1913) published a report on the common occurrence of a newly discovered nematode, later named Tylenchulus semipenetrans Cobb, 1913, on citrus trees and pointed out its relationship to citrus roots. Next year, Cobb published an elaborate account of citrus nematode, T. semipenetrans. He concluded by saying, "There can be no doubt that T. semipenetrans is an injurious parasite"! After the publication of this paper, various authors have tried to establish the pathogenicity of this parasite which has since then been a disputed question.

Recent workers have tried to establish the true damage caused by T. semipenetrans. Baines (1950) and Baines and Clarke (1952) have shown by means of controlled pot experiments the poor growth of citrus seedlings when inoculated with larvae of this parasite. Root injury due to these worms has been reported by White (1947). Marchionatto (1945) attributed rootlet-rot and chlorosis of the leaves to this parasite. Very recently, Baines et al. (1959) have reported that citrus nematode infested trees showed copper deficiency symptoms and grew 40-50 per cent slower than non-infested trees. Observations on life-cycle of this worm have been made by Gundy (1953). Control experiments have been conducted by Reynolds and O'Bannon (1958) who have succeeded with the use of 1,2dibromo-3-chloropropane as a soil drench. Similarly, Baines et al. (1957) and Baines et al. (1958) have found Vapam and

Mylone 85W respectively as promising nematicides.

Another important nematode attacking citrus trees is the burrowing nematode, Radopholus similis (Cobb, 1893) Thorne, 1949. In 1953, Suit and DuCharme published a paper titled 'Parasitic nematodes in relation to spreading decline of citrus' and discussed the effects of R. similis on feeder roots. Other nemic associates of citrus roots listed were: Hoplolaimus coronatus (= H. tylenchiformis), Pratylenchus pratensis, Trichodorus sp., Xiphinema americanum, Hemicycliophora sp. and Aphelenchus avenae. In 1957, the same authors described the economic importance, symptoms, cause and spread of the spreading decline of citrus, a disease caused by R. similis. They also discussed the behaviour, life-cycle and effects of R. similis on citrus roots. Studies on the reproduction of this nematode on citrus seedlings growing in petri-dishes have been made by Feder and Feldmesser (1955). Chitwood and Birchfield (1956) reported it as an important parasite of citrus in Florida and as being associated with slow decline of citrus groves and dwarfing of foliage on older trees. Birchfield (1956) and Birchfield and Bistline (1956) have listed various host plants of the burrowing nematode. In 1957, Birchfield discussed the burrowing nematode situation in Florida.

Fielding and Hollis (1956) have reported the occurrence of the following parasitic nematode species around roots of citrus trees in Louisiana: Tylenchulus semipenetrans, Pratylenchus spp., Paratylenchus sp., Tylenchorhynchus spp., Helicotylenchus spp., Rotylenchulus sp., and Xiphinema americanum.

The root-knot nematodes are not the usual parasites of citrus. However, Gundy et al. (1959) showed that Meloidogyne spp. can produce galls on roots of sour oranges.

Among the root-lesion nematodes, Pratylenchus pratensis has been listed as parasitic on orange, Citrus sinensis (Crossman and Christie, 1937), and has been reported from citrus roots by Suit and DuCharme, 1953. In their general survey of the occurrence of Pratylenchus spp. in Florida, Feldmesser et al. (1956) have also listed citrus as a host to lesion nematodes and have suggested that the parasites might be associated with damage to commercially valuable Florida crops. Allen and Jensen (1951) have found Pratylenchus vulnus, the primary pest of black walnut, Juglans hindsii Jepson, as also parasitizing citrus trees in California. How far this worm causes damage to citrus trees is still to be seen.

The scale and ring nematodes, Criconema and Criconemoides spp. have also been reported as parasite of citrus. Criconema civellae and Criconemoides citri have been reported by Steiner (1949) as feeding on citrus roots. Criconema multisquamatum (Kirjanova, 1948) Chitwood, 1957, is known to occur around citrus roots in U. S. S. R.

Gundy found Hemicycliophora arenaria Raski, 1958, attacking rough lemon, Citrus limonia Osbeck and has shown that it is destructive to rough lemon seedlings producing galls on root tips (Gundy, 1957, 1958).

Among the members of Dorylaimoidea, Trichodorus and Xiphinema spp. have been found attacking citrus roots, but nothing is known about their effects on citrus.

Technique

Various techniques have evolved for the isolation and examination of nematodes from soil and plant tissues (Stöchli 1943, 1950; Stöchli and Overgaard (1948); Christie and Perry (1951); Anderson and Yanagihara (1955); Tarjan, et al. (1956); Caveness and Jensen (1955); Feder and Feldmesser (1954); and Esser (1957). These techniques are mainly modifications based on Baermann principle and Cobb's sifting and gravity method.

The author has used the following method, which is both convenient and reliable, in the qualitative as well as quantitative determinations of nematodes.

Root and soil samples from citrus trees were collected and kept in plastic bags until they could be processed.

Soil samples: Baermann funnel technique was found unsuitable as some of the nematodes, e. g. dagger nematodes, do not come down through the cloth screen but wriggle in the debris over its surface. The soil samples were directly put in a bucket three-fourths filled with tap water and vigorously roiled. After about a minute or so, when the heavier sand particles had settled down the supernatant fluid was sieved twice with a gradation of Endecott's Test Sieves. Three sieves with apertures of 699, 124 and 66 microns were used. The nematode-debris residue caught on the sieves was then washed off into a basin and concentrated by decantation for nematode counts. While screening the aliquot through sieve with the finest aperture, it was found that the finer sand particles which were trapped on the mesh blocked the passage of water. This difficulty was overcome by gently tapping the lower surface of the sieve. Once more, the contents

of the bucket were sieved in the same manner to ensure that almost all the nematodes present in the sample were collected.

Root samples: The removal of the roots from the soil was done with utmost care because the semipenetrated and closely adhering citrus nematodes, T. semipenetrans, would be, otherwise, easily removed. The roots were slowly washed with water to get rid of the adhering soil, gently blotted and weighed. They were then chopped up into small pieces, the largest piece not exceeding 1 cm. The root pieces were transferred to large-sized petri-dishes filled with water. After about 24 hours, the aliquot was sieved twice with 66 microns aperture sieve and the washings were stored for nematode counts. The petri-dishes were again filled with water and the process was repeated every day for one week to get most of the evacuation.

To get a clear suspension of active nematodes: Whenever a clear suspension of nematodes free from debris was required, the nematode-debris suspension was processed as follows: Sieve with 66 microns aperture was tightly fitted to the lower container of the sieves (or bottom trough). The lower container was then filled with water till the meshes of the sieve completely dipped in water. The water-nematode-debris mixture was then slowly poured over the meshes and the set was left for about 12 hours. By this time, most of the living nematodes migrated down to clear water of the container and were then easily concentrated by decantation.

Counting the nematodes: The nematodes thus recovered from soil and root samples were counted by transferring them into

rectangular, flat-bottom glass trough whose bottom was scribed to give ten equal divisions. The nematodes were counted in each division under a binocular microscope. If there was a large number of nematodes to be counted the aliquot was diluted and made up to 100 c.c. It was then thoroughly agitated to give an almost uniform suspension. Three samples of 5 c.c. each were pipetted out and the nematodes in them were counted as described above. A mean of these three counts was calculated which was accordingly amplified to represent the total number.

To estimate the density of population of lesion nematodes within citrus roots:

It was found that the evacuation of root-lesion nematodes from citrus roots was rather slow and, in many instances, it was necessary to keep the roots immersed in water for more than four weeks to get a complete evacuation. Throughout this period the nematodes— males, females and larvae, kept on evacuating the roots in nearly the same ratio, although sometimes the freshly hatched larvae were in larger numbers. Athough the period of evacuation depends largely on the potential of infection and temperature of the water, a typical instance, in which about 100 per cent evacuation took place in 5 weeks, is cited below.

Two root samples from a nursery-grown infected lemon tree were collected on 26th August, 1957. The samples were washed in tap water and mixed together. Ten grammes of roots were then separated out and chopped up into small pieces, the largest piece not exceeding 1 cm. in length. These were then put in a petri-dish filled with tap water. The aliquot of the dish was

examined every day; the dishes being refilled with water daily. The nematodes which evacuated every 24 hours were counted. The data are given below in Table 1.

Table 1. Number of lesion nematodes evacuating citrus roots in every 24 hours.

Date of examination	No. of nemas evacuated	Date of examination	No. of nemas evacuated
27. 8. '57.	208	10. 9. '57.	78
28.	126	11.	148
29.	54	12.	129
30.	53	13.	324
31.	72	14.	196
1. 9. '57.	50	15.	154
2.	74	16.	142
3.	56	17.	118
4.	66	18.	223
5.	85	19.	120
6.	94	20.	140
7.	88	21.	106
8.	72	22.	116
9.	102	23.	128

Table 1. (Cont.)

Date of examination	No. of nemas evacuated	Date of examination	No. of nemas evacuated
24. 9. '57.	108	1. 10. '57.	17
25.	93	2.	4
26.	68	3.	0
27.	35	4.	0
28.	39	5.	0
29.	22	6.	0
30.	18	7.	0

Approx. total evacuation = 3660.

It is seen from the above observations that about 100% evacuation took place in five weeks, while only 5.6% in 24 hours and about 17% of the total population of worms evacuated in the first week.

Important parasitic nematodes attacking citrus trees in U. P.

Nematodes parasitizing citrus trees in U. P. include some of the notorious pests whose parasitism and pathogenicity have been established by many workers. The following account relating to important groups of parasitic nematodes which attack citrus trees in U. P. will help in a better understanding of

the nematode diseases of citrus in this region.

1. The root-lesion or meadow nematodes, Pratylenchus spp.

Two species of the root-lesion nematodes, Pratylenchus musicola (Cobb, 1919) Filipjev, 1936, and P. grandis n. sp. have been found associated with citrus roots at Aligarh. One of these, P. musicola, is widely distributed in Western U. P. These worms live in the cortex of the feeder roots. The typical brownish-black lesions on roots are caused due to the presence and feeding of P. musicola. The other host plant of this parasite in U. P. is banana, Musa paradisiaca L.

Root-lesion nematodes are one of the most serious phyto-parasites of plants and trees. Among the species attacking trees may be mentioned P. vulnus Allen and Jensen, 1951, on black walnut (Allen & Jensen, 1951; Lownsbery, 1956); olive, citrus, fig, apricot, almond, peaches (Allen & Jensen, 1951), avocado (Sher et al. 1959); P. penetrans (Cobb) on cherry (Mai & Parker, 1956), apple (Boscher & Newton, 1956; Ark & Thomas, 1936; Thorne, 1948); P. brachyurus (Godfrey) on pineapple. Thus, it is evident that lesion nematodes are important parasites of fruit trees.

2. The citrus-root nematode, Tylenchulus semipenetrans Cobb.

The citrus-root nematode appears to be widely distributed in Indo-Pakistan Sub-continent. The nematode is largely confined to members of citrus family. The adult female is an obligate parasite. It becomes obese and leads a sedentary life. Around the head of females necrotic lesions are usually seen on rootlets. The worms are not generally found on the decaying or dead roots.

3. The dagger nematodes, Xiphinema spp.

Three species of dagger nematodes viz. X. americanum Cobb, X. basiri n. sp., and X. citri n. sp., occur around citrus roots in U. P. The first two have been collected in sufficiently large numbers around citrus roots while the last one appears to be a rare parasite. Sometimes the worms are found in sufficiently large numbers to cause disorders. It is quite likely that the dagger nematode situation is serious in this region.

The dagger nematodes live permanently in soil and feed on plant roots from outside. They are not evenly distributed around roots but form colonies of hundreds and some times thousands at a particular place. When freshly screened out of soil into water, they show vigorous movements which later, start slowing down. This is possibly due to lack of proper aeration and change of medium. They are migratory parasites and, as described by Hollis et al. (1956), slow in reproduction.

Various workers have established the pathogenicity of dagger nematodes. Schindler (1954, 1957), with the help of controlled experiments, has proved the pathogenicity of these parasites. Gall-formation and curly-tip effect on the roots of rose, tomato, soya bean, okra, cucumber, balsam and peanut grown in soil infested with these worms have been shown by Schindler (l. c.). Schindler and Braun (1957) have proved that X. diversicaudatum is pathogenic towards strawberries. Recently Berry (1958) has found X. americanum and X. chambersi associated with a decline of strawberries in Wisconsin. The former species is supposed to be causing root injury to azaleas and laurel oak, Quercus laurifolia in Central Florida

and on pecan seedlings in Alabama (Christie, 1952). Adams (1955) has shown this nematode to be injurious to peaches and apple trees.

It may, therefore, be presumed that the dagger nematodes attacking citrus trees in U. P. are a reasonable source of danger to the citrus production.

4. The ring nematodes and their allies, Criconema, Criconemoides and Hemicriconemoides.spp.

Criconemoides parvulum n. sp., C. citri Steiner, 1949, and Hemicriconemoides mangiferae n. sp. are found in large numbers around citrus roots at Aligarh. These are also well distributed in U. P. Another species, Criconema tenuicaudatum n. sp. has been collected around roots of Citrus limon at Bhowali in Nainital District (U. P.).

The ring nematodes and their allies are usually small, thick-bodied forms, with heavily annulated cuticle. They usually lie half-buried on the rootlets and feed in the same position. Despite their odd-looking bodies, they often show active movements.

The importance of these worms as plant parasites is now largely being recognized and a lot of damage has been attributed to them. A large number of species are known to feed on plant roots. A species of Criconemoides was found to be associated with peanut yellows in Georgia by Machmer in 1953 and in South Carolina by Graham, 1954. The latter author has studied the ring nematode damage to tobacco and peanuts (Graham, 1954, 1955). Chitwood (1949) described C. similis Cobb, 1918, as 'A possible factor in decline and replanting problems of peach orchards'. When present in large numbers C. similis caused chlorosis, stunting and leaf-dropping in peach seedlings (Chitwood and Oteifa, 1952). C. rusticum was

found by Menzel (1941) as parasitizing grapewines and Jackson (1948) regarded it as a cause of root destruction and little leaf disease of pine seedlings. Sher (1959) attributed the disease of decline of carnations to Criconemoides xenoplax Raski.

5. The stunt nematodes, Tylenchorhynchus spp.

Two species of the stunt nematodes viz. Tylenchorhynchus indicus and T. bivittatus infest citrus soils in Aligarh and Banda districts (U. P.). As to how far these are a source of danger to citrus trees is still to be seen. However, recent workers have definitely proved that Tylenchorhynchus spp. are phytoparasites. Chitwood and Birchfield regard them as migratory, ecto- as well as endo-parasites of economic importance. The tobacco stunt nematode, T. claytoni Steiner, which was originally described as an apparently rare nemic parasite of tobacco plant has now been found to be widely distributed in Eastern States of U. S. A. (Reynolds and Evans, 1953; Graham,,1954). Krusberg (1959) described it as one of the more serious parasitic nematode in North Carolina. He discussed in detail the life-cycle, reproduction, feeding habits and host-range of this parasite. Similarly, T. dubius (Bütschli), which was largely being looked upon as a common soil inhabiting form, is now proved to be an important parasite of Cotton and beans (Reynolds and Evans, 1953). T. martini Fielding has been shown to be parasitic on rice and sugarcane roots (Fielding, 1956; Birchfield and Martin, 1956; Martin and Birchfield, 1955)

In all, seven species of stunt nematodes have been collected around roots of plants and trees in U. P. The author has found T. rugosus n. sp. feeding on root-tips of Mentha sp. and Brassica

oleracea L. The worms are well adapted to live in soil and survive without host plants. T. rugosus and T. brassicae n. sp. have been found by the author to survive in water for more than two months, living on their reserve food material stored in the intestinal cells. At the end of two-and-a-half months of starvation the worms were still active but the bodies appeared almost transparent.

6. The lance nematodes, Hoplolaimus tylenchiformis Daday.

The lance nematodes, Hoplolaimus tylenchiformis Daday, 1905, (= H. coronatus Cobb), are widely distributed in U. P. In several localities of Aligarh, lance nematodes occur in large numbers around citrus roots, and it would be remiss not to recognize their pathogenic significance.

The lance nematodes are well adapted to live in soil as well as within roots. The author has found them living in water without food for three months. Steiner (1949) gave the example of seedlings of Pinus palustris Mill. as being attacked by these worms in Florida nurseries. Viggars and Tarjan (1949) have related H. coronatus (= H. tylenchiformis) with a virulent disease trouble of pine and red oak in Wilmington, Delaware. They have listed a number of disease symptoms which are invariably related with the association of this nematode.

Very recently, Krusberg et al. (1955) and Krusberg and Sasser (1956) have made detailed study of host-parasite relationship of H. coronatus in cotton roots. They report the damage being caused to cortical, endodermal, phloem and xylem tissues of the cotton roots.

Distribution and prevalence of the nematodes parasitic on citrus trees in U. P.

Citrus trees in U. P. are very widely attacked by nematodes. Many kinds of nematodes are, more or less, always present in and around feeder roots, feeding voraciously on root tissues and producing thereby varied types of lesions. In the nematode complex of citrus trees, as is shown by the present survey, the meadow or lesion nematodes are the dominant constituent. In the present survey, data were collected for root-lesion as well as various other parasitic nematodes of apparently pathogenic significance.

Five kinds of citrus trees viz. (1) Citrus limon (L.) Burm., (2) C. sinensis (L.) Osbeck, (3) C. reticulata Blanco, (4) C. medica L., and (5) C. aurantium L., were examined and the data given here (Table 2) represent a mixed result irrespective of the kind of citrus tree. It is worthy to be mentioned here that C. limon and C. reticulata were found to be severely affected by lesion nematodes. No precise survey of the relative abundance of these pests in respect to a particular kind of citrus tree was made.

The root-lesion nematodes, P. musicola (Cobb); the dagger nematodes, Xiphinema spp.; the ring nematodes and their allies, Criconemoides and Hemicriconemoides; and the citrus-root nematode, Tylenchulus semipenetrans Cobb are the ones to which may be attributed a great deal of root destruction. Besides these, the following parasitic species were also collected during this survey: Hoplolaimus tylenchiformis Daday, 1905; Tylenchorhynchus indicus and T. bivittatus n. spp.; Rotylenchulus reniformis Linford and Oliveira, 1940; Ditylenchus nanus n. sp.; Paratylenchus

sp.; Aphelenchoides aligariensis n. sp.; Helicotylenchus erythrinae (Zimmermann) Golden, 1956; and Boleodorus citri n. sp.

Some of the saprozoic, scavanger and predaceous spp. such as Cephalobus, Acrobeles, Mononchus, Discolaimus etc., have also been found around citrus roots.

Root and soil samples of citrus trees were examined from 13 districts covering Eastern, Central, Southern, Western and Northern regions of U. P. Samples were collected and examined by the writer. The data given in Table 2 represent the result of examination of 189 samples of roots and as much of soil from 89 citrus trees originating in 13 districts of U. P. In case with root samples data only for lesion nematodes are given. Each root sample weighed approximately 10 gms. and that of soil 100 gms.

These data, although representing the results of only few samples examination, put up an alarming situation as regards the nematosis of citrus trees in Uttar Pradesh. As the survey-work was not precisely systemmatic and on a large scale, it is not unlikely that the nematode diseases of citrus are present in many of the unreported localities. The data show that in the western districts of U. P. the endoparasitic nematode, P. musicola, is an important predominant parasite. The dagger nematodes especially X. americanum are very widely distributed in U. P. The ring nematodes, the citrus-root nematodes and the lance nematodes are also fairly well distributed in this State.

The distribution of parasitic nematodes based on the results of the present survey of citrus trees in U. P. is shown in the following map. The districts surveyed have been named and the district headquarters have also been shown. The latter represent the collection sites.

Table 2. Distribution of nematodes attacking citrus trees in Uttar Pradesh.

Districts (date of collection)	No. of samp. / No. of trees	P. musicola (Root samples)	P. musicola (Soil samples)	C. citri	C. parvulum	X. americanum	X. basiri	H. tylenchif.	Tylenchulus semipenetrans	Tylenchorhynchus spp.
Aligarh Jan-March,'57	48/24	70398	445	147	546	3318	1335	850	493	153
Badaun Dec., '57	10/4	421	58	15	68	42	0	15	112	0
Banda Dec.-Jan.,'59	18/10	0	0	49	85	32	0	19	0	113
Basti, March, '57	16/9	0	0	0	165	32	0	28	0	0
Bulandshahr Jan.,Feb.,'57	11/6	19283	212	18	517	68	32	28	164	0
Etah Dec. '56	6/3	234	47	15	36	13	0	14	76	18
Gonda Nov., '56	6/2	0	0	0	21	0	0	6	0	12
Hamirpur Dec., '59	6/2	0	0	0	78	19	0	0	0	0
Jhansi Dec., '57	12/6	0	0	54	62	32	87	15	78	0
Kanpur Dec., '57	8/4	0	0	0	0	4	0	21	0	0
Meerut Dec., '58	20/10	25817	257	54	1214	113	212	88	1251	76
Nainital June, '58	8/4	0	0	17	0	4	0	0	8	0
Pilibhit Feb., '59	10/5	0	0	0	0	41	17	19	0	0


DISTRIBUTION OF NEMATODES
ATTACKING CITRUS TREES
IN UTTAR PRADESH
Pratylenchus musicola
Tylenchulus semipenetrans
Xiphinema americanum
Xiphinema basiri
Criconemoides citri
Criconemoides parvulum
Tylenchorhynchus indicus
Helicotylenchus erythrinae
Haplolaimus tylenchiformis
District Head-quarter(coll site)
MEERUT
BULANDSHAHR
ALIGARH
ETAH
BUDAUN
BILSHI
KANPUR
HAMIRPUR
JHANSI
BANDA
GONDA
BASTI
0 30 60 90 120 MILES

Figure 1

Relative abundance of nematodes in the nematode-complex of citrus trees in Aligarh (U. P.)

For determining the relative abundance of parasitic nematodes of citrus in Aligarh a general survey was conducted during the months of January, February and March, 1957. Citrus trees growing in nurseries, private gardens and orchards within or in the vicinity of University Campus were selected for this study. Few root and soil samples per tree were collected in a random way usually at a distance of 2 feet from the trunk and at 2-6 inches depth. They were separately mixed and randomized. Only two samples of roots and as much of soil each weighing 10 and 100 grammes respectively were sorted out and processed for determining the nemic contents. The data obtained for 48 such samples of roots and as much of soil are incorporated in Table 3. It is evident from these data that the root-lesion nematodes constitute the dominant factor in the nematode-complex. Percentage sample frequency of various nemic parasites is also quite high. Both the ecto- and endo-parasites occur in sufficiently large numbers to cause disorders.

These data also show that Xiphinema americanum occurs more frequently and in larger numbers in soil around citrus roots than X. basiri which is an important parasite of oranges. It is important to mention here that in the case of reniform nematodes, Rotylenchulus reniformis Linford & Oliveira, 1940, only the larvae, males and immature females were collected. The adult obese females were not encountered.

Table 3. Relative abundance of nematodes attacking citrus trees in Aligarh District (U. P.).

NEMATODES	48 soil samples of 100 gms. each from 24 trees (2 samples per tree)				48 root samples of 10 gms. each from 24 trees (2 samples per tree)			
	Total no. estimated from all 48 samples	%age sample frequency	Av. no. per infested sample	%age of total number	Total no. estimated from all 43 samples	%age sample frequency	Av. no. per infested sample	%age of total number
Pratylenchus musicola	445	56.2	16	5.3	70398	64.5	2270	92.4
Tylenchulus semipenetrans	493	54.1	19	6.4	4438	60	150	5.8
Xiphinema americanum	3318	83.3	83	43.4	133	50	5.5	0.17
Xiphinema basiri	1335	35.4	78	17.4	102	29.1	7.2	0.13
Criconemoides citri	147	45.8	7.1	1.9	149	27	11.4	0.19
Criconemoides parvulum	546	31.2	36	7.1	238	29.1	17	0.31
Hoplolaimus tylenchiformis	850	62.5	28	11.1	498	54.1	19.1	0.65
Helicotylenchus erythrinae	166	52.0	7	2.1	56	33.3	3.5	0.07
Tylenchorhynchus spp.	153	47.9	7	2.0	64	13.7	7	0.08
Rotylenchulus reniformis	182	20.8	18	2.3	4	4.1	2	traces

Etiology of the root-rot of citrus

The typical brownish-black lesions, which are found on the feeder roots of citrus trees, are always infested with root-lesion nematodes, Pratylenchus musicola (Cobb). The field as well as laboratory observations, as will be seen later, have shown that such lesions are caused by these nematodes. These worms range from 0.48-0.71 mm. in length and do not show marked sexual dimorphism. The vigorous, hollow buccal stylet and the slenderness of the body are most suitable for the endoparasitic mode of life. A detailed morphology of this worm and its systematic position have been discussed in Part 1 of this work.

Pratylenchus musicola was originally described by Cobb in 1919 from roots of 'Bluggoe' banana in Grenada, West Indies. Taylor and Loegering (1953) reported it from roots of abacá, Musa textilis Neé, occurring in Costa Rica, Panama, Honduras and Phillipine Islands. It is interesting to note that it has never been reported as a parasite of citrus trees. These eelworms live and reproduce in the cortical tissues of the feeder roots. Their presence and feeding on neighbouring cells inflict injury to the latter which, consequently, start decaying, resulting in the formation of a tiny lesion which later expands as the infestation proceeds. The worms quit the rotting or decaying tissues. They infest only the healthy rootlets.

The larvae and the adults are capable of entering a rootlet and feeding on its cortical tissues. Their bodies usually lie parallel to root axis. The eggs are laid by the females in situ. The eggs laid in soil or in water are also capable of hatching

out. In the rootlets, the eggs are usually found lying parallel to the axis of the root. The larvae develop and grow to maturity by feeding on the cortical cells. The worms have been found to live without food for over two months.

Studies on egg-laying and hatching in P. musicola (Cobb)

While studying the host-parasite relationship of P. musicola, it was proposed to study the rate of oviposition and the time required for hatching of the eggs within and outside root tissues.

Some workers have ventured to investigate into the life-cycle of lesion nematodes, Pratylenchus spp. While working on a species, Pratylenchus pratensis parasitizing oats in Canada, Hastings (1939) was probably the first who could successfully work out the complete life-cycle in this group of eelworms. According to him the life-cycle in this worm is completed in 54-65 days. He estimated that the period from larval stages to the adult is 25-31 days and that 29-34 days are required from maturation to the second generation. In connection with the egg-laying he suggested that the females do not lay more than one egg per day.

In Ceylon, Gadd and Loos (1941) studied the life-cycle of P. pratensis attacking tea plants. The nematode requires 45-48 days for the completion of its life-cycle. The eggs are reported to hatch in 15-17 days though they may even hatch within a shorter period of 12 days in vitro. The larval stages lasted for 15-16 days and about 15 days were needed for the adult females to start laying eggs.

Graham (1951), while working on P. zeae attacking corn, estimated the life-cycle to require 35-40 days at a temperature of 75-80°F.

Tarjan (1950) studied the rate of oviposition and the time required for hatching of the eggs of Pratylenchus sp. from boxwood.

The following experiments were designed to study the rate of oviposition, the process of development of larva within egg-shell and the time required for hatching out of the larvae.

Egg-laying and hatching (in water) of P. musicola

Procedure: A series of 10 pairs of petri-dishes, 13 cm. in diameter and 3 cm. high, were selected for this purpose. In the top-half of each of these dishes 5 drops of tap water were put in such a way that when the top-half was replaced over the bottom half the drops hanged down. Into each of the five drops of each set a gravid female (with a visible uterine egg) of P. musicola was transferred through a capillary pipette. These nematodes were obtained from roots of Citrus limon by the process mentioned earlier. Thus 50 gravid females, each in a single drop of water, were under study at one time. The bottom-half of each set was partly filled with water. The top-half of the dish, with nematodes in the hanging drops, was later placed gently over the bottom-half. Thus, with this device, a small moisture chamber was produced to check the hanging drops from becoming dried up. All the 10 sets of petri-dishes were later transferred to a constant temperature cabinet whose range of temperature fluctuation was from 80-85°F. After each 24 hours,

the hanging drops were examined for the females and the eggs they laid under a binocular microscope giving a magnification of 20 by 45 which was suitable to allow a proper study.

Observations: After 24 hours of the transference of the gravid females into the drops, 28 females had laid one egg each and were quite active; 14 remained quiscent; and 8 failed to lay an egg although there was a mature egg in the uterus of each and the females were active. In 48 hours, 12 females laid another egg and were active; 14 females that remained quiscent showed bacterial growth over their bodies suggesting that they were dead; 8 females that had not laid any egg were active but none laid an egg. In 72 hours, five females laid their third egg and were active; the remaining 31 females, although quite active, never laid an egg. After 72 hours no female was seen laying an egg and the oviposition totally stopped. Many of the active females showed movements of their bodies up to 15 days. By this time, the intestinal contents of the body were almost used up and the worms appeared rather transparent. The results of this study are summarized in Table 4.

These data show that more than 50% of the females had laid one egg within 24 hours, about 25% were able to lay a second egg and only 10% laid a third egg. The obvious reason as to why the females failed to lay more eggs is chiefly the absence of food. Moreover, there is the possibility of the females getting injured during isolation and transference to hanging drops. The rate of oviposition within roots, where the supply of food is abundant, is presumed to be much higher than in the present case.

Table 4. Egg-laying in P. musicola (in water)

Time	No. of females that laid eggs.	No. of females that did not lay eggs	No. of females that were quiscent (dead)
24 hours (1st egg)	28 (56%)	8	14
48 hours (2nd egg)	12 (24%)	8, 16	14
72 hours (3rd egg)	5 (10%)	8, 16, 7	14
96 hours (4th egg)	0	8, 16, 7, 5	14

Studies on the development and hatching of eggs of P. musicola in water

Studies were made on the development of eggs of P. musicola from the time of oviposition to hatching. The eggs laid by the females in the hanging water drops, as described in earlier experiment were regularly examined under different intervals under a binocular microscope of 20 by 45 magnification. In all, 45 eggs were under study. The temperature of the cabinet fluctuated from 80-85°F.

After every third day the volume of water in each drop was made normal by the addition of more water through a dropper.

The eggs of P. musicola are generally laid unsegmented; in some cases 2-4-celled stages are also encountered in freshly laid eggs. As soon as the egg is laid the development starts. After about 6-8 hours the eggs are seen in 3-8-celled stages. In about 32-48 hours the egg-mass becomes a compact, multicellular structure which usually does not fill the whole of the egg-shell cavity. The eel-like larva is formed in 3-4 days and on the 6th day the larva is seen wriggling inside the egg-shell. At this stage the larva measures from 155-175 microns in length. The egg residue is seen as a granular, spherical mass lying near one end of the egg (Fig. 2, F). On the 7th day the larva considerably grows and almost fills the whole of the egg-shell cavity. It makes vigorous recoiling movements inside the egg. The egg itself becomes much enlarged and the larva grows considerably. It now measures 180-195 μ in length; the buccal spear is 11-12 μ long; median oesophageal bulb with valvular apparatus is distinct; intestinal cells have spherical, refractive granules (Fig 2, G).

On the 8-10th day the larva considerably grows and keeps on making constant movements inside the egg-shell. By this time the egg-shell becomes thin, membranous, and much distended due to the increased size of the body of the larva.

Finally, on the 10-13th day the larva hatches out by the rupture of the membranous egg-shell. The newly hatched larva

measures 0.195-0.21 mm. in length. The buccal spear and oesophagus are clearly seen; the intestine, however, appears to have very few food granules.

In all, only 7 out of 45 eggs could develop up to 10th day; 4 of these hatched, while other 3, although having well developed larva, failed to hatch. Among other eggs that were under study some developed up to the 6th day, some only up to the multicellula stage while others did not exceed beyond 8-celled stage.

Phenomenon of endotokia matricida observed in P. musicola

The phenomenon of endotokia matricida was described in Rhabditis sp. by Paetzold (1958). In this the worm fails to lay eggs which start developing within the body of the mother; the larva hatch out inside its body, bore their way into the body cavity and feed on the internal organs thereby killing the mother nematode. Loof (1959) described this phenomenon for the first time in members of Tylenchida. He found a female of Pratylenchus coffeae (Zimmermann) with five eggs and one larva developing inside the body. Similarly a female of Aphelenchoides fragariae (Ritzema-Bos) was found to have a larva inside the body. In the literature, however, there is no other record of this phenomenon occurring in Tylenchida. The author encountered an example of this phenomenon in P. musicola (Cobb) attacking roots of citrus trees at Aligarh. In August, 1957, a female measuring 0.664 mm. was isolated from citrus roots. It had some nine eggs piled up inside the body. Two of these eggs had well

developed larvae. The ovary was pushed up and the spermatheca was only about one body diameter behind oesophageal glands. Measurements of the female and its eggs are given below.

Female: Length = 0.664 mm.; a = 21; b = 3; c = 19; V = $^{77.7-}_{82.2}{}^{-4.8}$%.

1st egg = 48 μ by 23 μ; 2nd egg = 46 μ by 24 μ; 3rd egg = 48 μ by 23 μ; 4th egg = 48 μ by 23 μ; 5th egg = 49 μ by 23 μ; 6th egg = 49 μ by 23 μ; 7th egg = 54 μ by 21 μ; 8th egg = 52 μ by 22 μ; 9th egg = 45 μ by 22 μ.

This is the second report of the phenomenon of endotokia matricida found in members of Tylenchida.

Studies on host-parasite relationships of P. musicola

Host-range of P. musicola.

The lesion nematode, P. musicola, has been found attacking Citrus limon (L.) Burm., C. reticulata Blanco, and C. sinensis (L.) Osbeck and Banana, Musa paradisiaca L. Of these, lemon and and banana have been found to be severely attacked. The species attacking banana is morphologically indistinguishable from that attacking citrus. The transfer experiments, as will be seen later, have shown that these two are physiologically the same species. No other congenial host plant was found in U. P.

Experiment 1. Citrus seedlings acquire infection if grown close to banana plants infested with meadow or lesion nematodes.

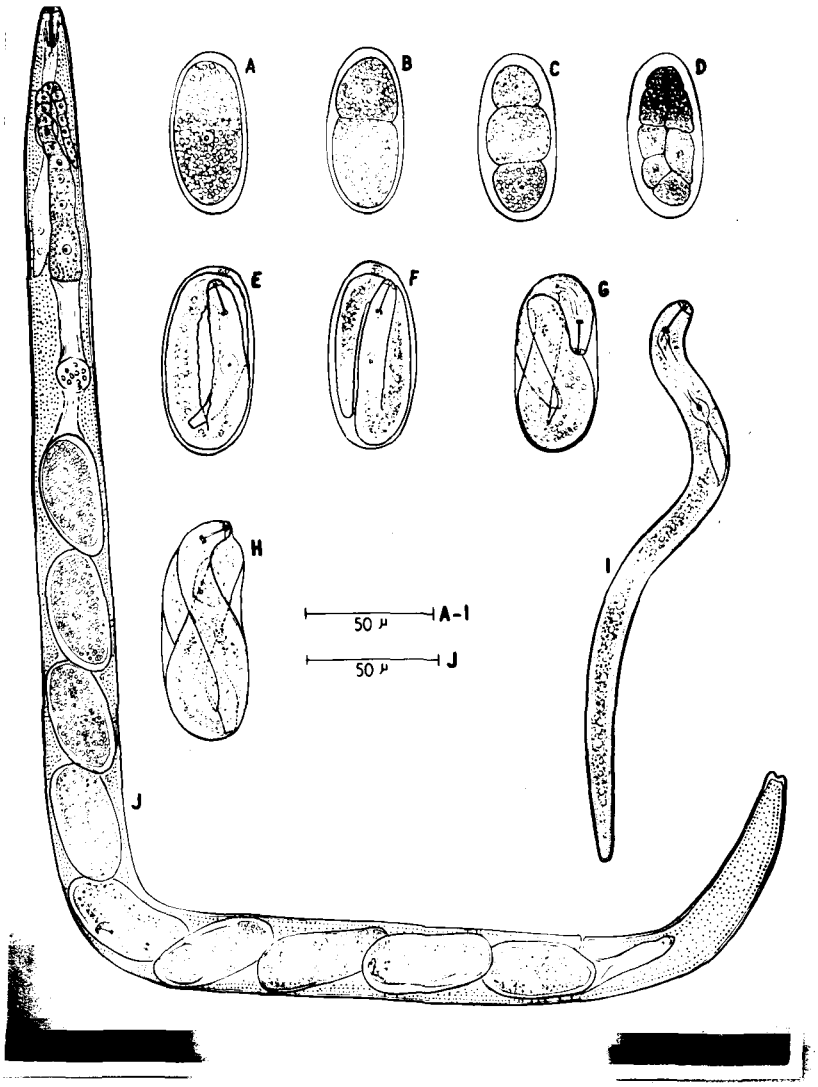


Figure 2.

Development of eggs of P. musicola and the phenomenon of 'Endotokia matricida'.

Figure 2., A-J. A-H, stages in the development of egg; I, newly hatched larva; J, female of P. musicola with nine eggs.

Four one foot tall banana plants taken from lesion-nematode infested stock were transplanted in 12" pots filled with steam-sterilized soil. Two 15 days old lemon seedlings (C. limon) that were grown under asceptic conditions were transferred to each of these pots. Thus, each pot under study had one infected banana plant and two uninfected (clean) healthy lemon seedlings. These were left as such and were regularly watered. After a period of 8 months all the eight lemon seedlings were pulled of soil and examined for lesion nematode injury on roots. Nearly all the seedlings were severely attacked by lesion nematodes. On an average 250 lesions were counted on the roots of each plant.

Experiment 2. Cross-inoculation of orange and lemon seedlings with lesion nematodes from banana roots.

Seedlings of lemon (C. limon) and orange (C. sinensis) were grown in steam-sterilized soil. After 15 days of sprouting, one seedling per pot having sterilized soil in it was transplanted in 20 pots in such a way that half of the pots received lemon and half the orange seedlings. Thus, there were two sets of 10 pots each; one set having lemon and the other orange seedlings. Five days after transplantation of the seedlings, half of the plants of each set were inoculated with varying doses of lesion nematodes from banana roots. The remaining, uninoculated seedlings served as controls. The inocula used in these tests were given two to three washings with tap water and were almost free of associated nematode species. The seedlings were examined after varying number of days. The results are presented in Table 5.

Table 5. Inoculation of lemon and orange seedlings with lesion nematodes from banana roots.

Citrus limon: Pot no.	Inoculum	Date of inoculation	Date of examination	Approx. no. of nematodes recovered
1.	50 gm. nematized roots	25.X.57	30.XII.57	120
2.	200 adults	25.X.57	4.I.58	360
3.	200 "	25.X.57	6.I.58	620
4.	250 "	25.X.57	6.I.58	870
5.	250 "	26.X.57	6.I.58	450
Citrus sinensis:				
1.	50 gm. nematized roots	22.X.57	30.XII.57	420
2.	200 adults	22.X.57	6.I.58	780
3.	200 "	29.IX.57	21.I.58	670
4.	300 "	29.IX.57	29.I.58	350
5.	1000 "	29.IX.57	29.I.58	780

The result of this experiment showed that all the citrus seedlings had acquired infection and the controls were absolutely free. The data, however, do not show a good increase in population.

This was not due to the incapability of the worms to multiply within the citrus roots because the nematodes that recovered from the roots included a number of newly hatched larvae. On the other hand the decline in population may be attributed to irregularities in watering the plants, excessive heat and the decaying conditions of the roots.

Experiment 3. Cross-inoculations of orange seedlings with lesion nematodes from lemon roots and vice versa.

The procedure adopted in this case was essentially the same as in Experiment 2. There were two sets of 6 pots each. Set 1 had one orange seedling ~~seedling~~ (Citrus sinensis) and set 2 one lemon seedling (C. limon) in each pot. Half of the pots in set 1 were inoculated with varying doses of P. musicola isolated from roots of C. limon and, similarly, half of the pots in set 2 received inoculum from roots of C. sinensis. The remaining pots served as controls. The plants were examined for the presence of lesion nematodes in roots after varying periods of times.

The controls gave negative results. The result of examination of inoculated plants is given in Table 6.

The data of all the above three experiments show that P. musicola attacking banana and citrus in U. P. is, physiologically, the same species. It is able to reproduce and multiply within the roots of either of these hosts.

Table 6. Cross-inoculations of orange seedlings with lesion nematodes from lemon roots and vice versa.

Citrus sinensis: Pot no.	Inoculum (from lemon roots)	Date of inoculation	Date of examination	Approx. no. of nemas recovered
1.	250 adults	19.IX.57	20.I.58	3570
2.	250 "	23.IX.57	20.I.58	7840
3.	1500 "	21.I.58	21.VI.58	580
Citrus limon: **Pot no.**	**Inoculum (from orange roots)**			
1.	200 adults	22.X.57	22.III.58	1200
2.	200 "	22.X.57	22.III.58	970
3.	500 "	23.X.57	22.IV.58	5780

Pathological effects of P. musicola on citrus plants.

Field observations: The nematode root-rot disease of citrus is wide spread in western districts of Uttar Pradesh. In Aligarh the diseased trees are found nearly in every orchard, nursery, or private garden. Citrus limon (L.) Burm. and C. reticulata Blanco

are found to be worst affected. The symptoms of the disease include the poor growth of the trees, general dieback symptoms, production of under-sized fruits and so on. On the feeder roots, necrotic lesions caused mainly by the lesion nematodes are distinct The worms live in and feed on cortical tissues which may secondarily be invaded by various micro-organisms. Some times, whole of the cortex is destroyed and the woody core of the rootlet is left nacked. The general effects of the infestation by lesion nematodes is the ultimate reduction in the feeder root system. On the badly infested trees growth of new feeder roots may be very scarce.

Laboratory observations:

For determining the pathological effects of P. musicola on citrus plants the following experiments were designed.

Materials and method: As described earlier under Experiment 2, seedlings of C. limon and C. sinensis were grown in steam-sterilized soil and later, after 15 days of sprouting, were transplanted one to each pot having sterilized soil in it. Four replicates of four pots each with one seedling of C. limon per pot and as much with one seedling of C. sinensis per pot were selected for this study. Half of the plants of each category were inoculated with lesion nematodes while the other half served as controls. The inocula were secured from roots of C. limon and consisted mainly of the females. They were given 2-3 washings in tap water. 2-5 cc of water from inocula was introduced around the roots of the plants serving as controls. The pots with seedlings of C. limon received 250 worms per pot and the pots with C. sinensis

were inoculated with 500 worms per pot. The nematodes were released 1 inch deep into the soil just near the stem of the seedlings. All the pots were later transferred to a large-sized wooden frame-work wrapped in from all sides by a muslin cloth.

Table 7. Effects of P. musicola on citrus plants.

Citrus limon:	Inoculated seedlings		Controls	
	Replicate* 1	Replicate 2	Replicate 3	Replicate 4
Inoculum	250	250	0	00
Nemas recovered from roots	1200	980	0	0
Top weights in grammes	3.9	2.5	4.3	4
Root weights in grammes	2	1.4	4	3.8
Citrus sinensis:				
Inoculum	500	500	0	0
Nemas recovered from roots	4500	436	0	0
Top weights in grammes	1	0.8	4.8	4.5
Root weights in grammes	1.5	1	5.1	4.3

* Each replicate represents the average of 4 seedlings.

Effects of P. musicola on young citrus plants.

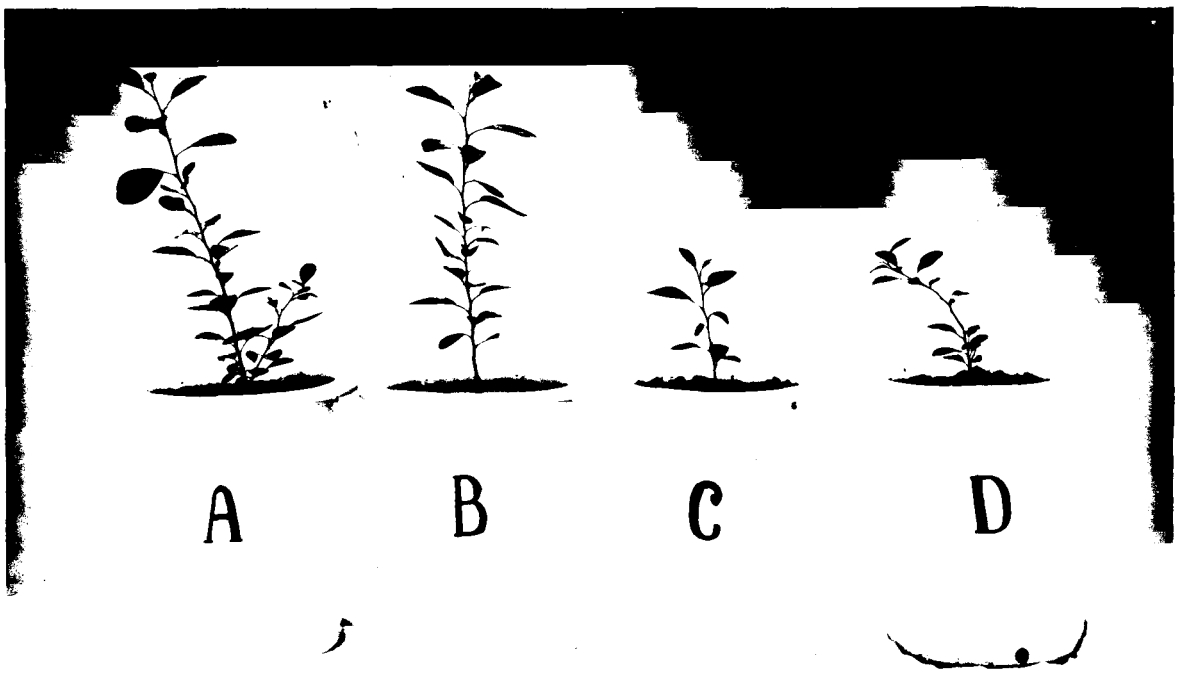


Figure 3

Figure 4

The pots were watered at regular intervals. Approximately four months later, the pots were taken out for examination. The roots were carefully pulled out of soil and the adhering soil was removed by washing them in a dish. The roots were then weighed and processed for nemic determination. The tops of the plants were also weighed. The soil of the pots was screened and the nematodes isolated were counted. The results are presented in Table 7.

Observations and discussions: The controls were found to be absolutely free of nematodes. The inoculated seedlings showed poor growth. Their roots had been badly damaged by the worms and the brownish black lesions were abundant. The root system was considerably reduced due to the infestation by these worms. The differences between inoculated and control plants were statistically significant though the infestation lasted for only about four months This marked difference in the growth of the seedlings suggests the pathogenic behaviour of P. musicola. The contrast seen here may also be due to comparatively poor resistance found in the young plants.

The populations of P. musicola increased both in lemon as well as orange roots, although, in certain case, the population decreased. This falling down of the population may be attributed to the absence of the healthy root system as well as certain other physical factors.

It may be concluded that P. musicola is pathogenic to citrus plants, causing a marked reduction in the top as well as root weights.

Control

Measures adopted in combating the plant parasitic nematodes may be summarized under the following heads.

(1) Cultural methods e. g. crop rotation, flooding, drying, overfertilization etc.
(2) Hot-water treatment.
(3) Soil fumigation.
(4) Chemotherapy.
(5) Use of resistant varieties.
(6) Biological control.

In controlling the nematodes attacking perennials rotation of crop or soil fumigation can not be used. Once the trees are attacked by nematodes it becomes very difficult to eradicate the infestation. Recently, Tarjan (1950) has pointed out a possible chemo-therapeutic measure, the use of sodium selenate, for controlling the nematodes attacking box-wood. Similarly, Renolds and O'Bannon (1958) have shown that citrus nematodes can be controlled by using 1,2 dibromo-3-chloropropane on living citrus trees. But still a successful chemo-therapeutic compound is not known. The general practice in combating eelworms attacking perennials is to destroy the infested stock, fumigate the site, and replant it with healthy seedlings which have previously been grown under asceptic conditions.

Efficacy of a diazinon compound (Basudin 20E) against lesion nematodes (*in vitro*).

Srivastava and Saxena (1956) have reported that 0.05% emulsion

of Basudin 20E, a 20% emulsifiable solution based on diazinon, when used as soil drench completely controlled paddy nematodes within 72 hours. Similarly, Srivatava and Katiyar (1956) have found the same chemical to be effective in controlling wheat-gall nematode when used as an aqueous solution of 0.1% strength. With these results in view, it was proposed to evaluate this chemical for the control of the lesion nematodes attacking citrus.

Materials and method: Through the courtesy of M/S Geigy Insecticides Private Limited the author received Basudin 20E in January, 1957. Basudin 20E is a 20% emulsifiable solution based on diazinon. Aqueous emulsions of various concentrations of this compound were prepared. These concentrations ranged from 250 to 25000 p.p.m. (parts per million). Hence, 0.25, 0.5, 2.5, 5, 10, 25 cc. of this mixture per litre of water was required to make solutions of 250, 500, 2500, 5000, 10,000, and 25,000 p.p.m. concentrations respectively. These solutions were immediately used after they were prepared. The test worm was P. musicola. Adult males and females were freshly isolated from citrus roots and kept in tap water under a petridish. 3-4 cc. of the solutions of various strength were separately taken in small-sized watch glasses and kept inside large-sized petri-dishes which contained small quantities of water. This device checked the alteration of the concentration of the solutions. Into the solution of each watch glass counted number of active nematodes (both males and females) were transferred with the help of a bamboo splinter. The nematodes remained in the solution for a specified time and then were taken out of the chemical and kept in fresh tap water. Those that recovered the effects and became active within 24 hours

were taken as 'alive' while the rest as 'dead'. The observations are incorporated in Table 8.

Table 8. Efficacy of Basudin 20E against P. musicola in contact nematicidal test.

Concentrations in parts per million	Time in hours	Nematodes dead	Nematodes living	% age mortality
250	30	0	15	0
250	48	0	15	0
500	48	4	16	20
500	84	6	16	27
2,500	30	3	7	30
2,500	72	7	33	70
5,000	48	4	6	40
5,000	84	18	2	90
10,000	30	9	1	90
10,000	48	15	0	100
10,000	72	15	0	100
25,000	20	15	0	100
25,000	30	15	0	100
25,000	48	15	0	100

The above data show that, in contact nematicidal tests, only high concentrations of Basudin 20E are nematicidal to P. musicola. Concentrations up to 5,000 p.p.m. fail to give a good mortality under 48 hours of exposure.

It is important to note that the above data give only the contact poisoning effects of Basudin 20E. If used as a soil drench, this chemical might give a greater mortality and prove to be a good nematicide because, when taken orally during feeding by nematodes, it might produce different effects.

The chemical control for the standing trees is a rather difficult task for the present. Till the time we get chemicals with a good nematicidal value at cheap rates, the control measures for citrus nematodes should be directed towards undertaking precautionary measures including isolation, destruction, iradication, soil managements etc.

The author has found that certain nurseries of Aligarh and Agra, which are the chief supplying agencies for citrus stocks in this region, are infested with many species of parasitic nematode Citrus seedlings from Agra nurseries showed typical lesion nematode root-rot. A few young seedlings showing poor growth had nematode injuries on roots. The author has collected Xiphinema americanum, X. basiri, Tylenchorhynchus indicus, T. bivittatus, Tylenchulus semipenetrans, Criconemoides citri, C. parvulum and Hoplolaimus tylenchiformis from citrus soils of U. P. Government Nursery located at Aligarh.

The first step to check the spread of the nematode diseases

of citrus should be to grow the citrus propagation stock under asceptic conditions. The nursery beds should be thoroughly fumigated prior to plantation of the propagatory stock. Secondly, when planting new citrus trees, care should be taken to sterilize the plantation site through fumigation or steam-sterilization. Thirdly, care should be taken that nematodes do not get entry into the new plantation sites. Parasitic nematodes are generally contacted from older trees or other alternative host plant standing nearby. Fourthly, practices leading to fresh infections common among citrus growers should be discouraged. For example, a general practice of the gardeners and growers in Aligarh is to remove the feeder roots of older citrus trees for getting better fruit yield. This is good if the roots thus removed are burnt or destroyed otherwise. But the growers bury such roots just near the trunk of the trees or scatter them out few yards away from it. This helps the nematodes to reach the uninfested trees.

Above all, there is a great need that the citrus growers should be trained to have at least an elementary knowledge of the plant nematodes, their behaviour and the possible control measures which can be adopted against them.

REFERENCES

Part I

Allen, M. W. 1952. Observations on the genus Meloidogyne Goeldi, 1887. Proc. Helm. Soc. Wash. 19 (1): 44-51.

_____, 1955. A review of the nematode genus Tylenchorhynchus. Univ. Calif. Publ. Zool. 61 (3): 129-166.

_____, 1957. A review of the nematode genus Trichodorus with descriptions of ten new species. Nematologica 2: 32-62.

_____, and H. J. Jensen. 1951. Pratylenchus vulnus, new speci (Nematoda: Pratylenchinae), a parasite of trees and vines in California. Proc. Helm. Soc. Wash. 18: 47-50.

Allgén, C. 1934. Freilebende marine Nematoden aus Hallands Väderö und der nahegelegenen Küste Schonens (Südschweden). Ein Beitrag zur Kenntnis der Nematodenfauna des südlichen Kattegatts. Folia Zool. et Hydrobiol. Riga, 6: 48-86.

Andrássy, I. 1952. Drei neue Arten aus der Superfamilie Tylenchoide: Nematologische Notizen 3. Ann. Biol. Univ. Hung. 2: 9-15

_____, 1954. Revision der Gattung Tylenchus Bastian, 1865. Acta Zool., Acad. Sci. Hung. 1 (1-2): 5-42.

_____, 1958. Erd- und Süsswassernematoden aus Bulgarien. Ibidem 4 (1-2): 1-88.

_____, 1959. Freilebende Nematoden aus Rumänien. Ann. Univ. Sci. Budapest. Rol. Eot. Nom. Sec. Biol., 3-27.

_____, 1959 a. Neue und wenig bekannte Nematoden aus Jugoslawien. Ann. Hist. Nat. Mus. Nat. Hung. 51: 259-275.

Bally, W., and G. A. Reydon. 1931. De Tegenwoordige Stand van het Vraagstuk van de Woortelaaltjes in de Koffiecultuur. Arch. v. Koffiecultuur. 5 (2): 23-216, Batavia.

Bastian, C. H. 1865. Monograph on the Anguillulidae. Trans. Linn. Soc., London. 25: 73-184.

Brown, G. L. 1956. Tylenchorhynchus lenorus, n. sp. (Nematoda: Tylenchida) associated with the roots of wheat. Proc. Helm. Soc. Wash. 23: 152-153.

Bütschli, O. 1873. Beiträge zur Kenntnis der freilebenden Nematoden Nova Acta der Ksl. Leop. -Carol. Deutsch. Akad. Naturf. 36: 1-144.

_____, 1874. Zur Kenntnis der freilebenden Nematoden, insbesonders der des Kieler Hafens. Abhandl. Senkenberg. Naturf. Ges. 9 (3): 273-292.

Butler, E. J. 1913. Diseases of rice, I. —An eelworm disease of rice. Bull. 34, Agric. Res. Inst. Pusa, India.

Cassidy, G. 1930. Nematodes associated with sugarcane in Hawaii. Hawaiian Plant. Rec. 34: 379-387.

Chitwood, B. G. 1949. Root-knot nematodes —Part I. A revision of the genus Meloidogyne Goeldi, 1887. Proc. Helm. Soc. Wash. 16: 90-104.

_____, 1957. Two new species of the genus Criconema Hofmänner and Menzel, 1914. Ibid. 24: 57-61.

_____, 1958. The classification of the plant-parasitic nemas and related forms. XVth International Congress of Zool. Sec. 8, Paper 28.

_____, and W. Birchfield. 1957. A new genus, Hemicrico-

nemoides (Criconematidae: Tylenchina). Proc. Helm. Soc. Wash. 24: 80-86.

Chitwood, B. G., and M. B. Chitwood. 1950. An introduction to Nematology. Part I. Monumental Printing Co. Baltimore, Md. 213 pp.

_____, C. I. Hannon, and R. P. Esser. 1956. A new nematode genus, Meloidodera, linking the genera Heterodera and Meloidogyne. Phytopath. 46 (5): 264-266.

Christie, J. R. 1942. A description of Aphelenchoides besseyi, n. sp., the summer-dwarf nematode of strawberries, with comments on the identity of Aphelenchoides subtenuis (Cobb, 1926) and Aphelenchoides hodsoni Goodey, 1935. Proc. Helm. Soc. Wash. 9: 82-84.

_____, 1952. Some new nematodes of critical importance to Florida growers. Proc. Soil Sci. Soc. Fla. 12: 30-39.

_____, and C. H. Arndt. 1936. Feeding habits of the nematodes Aphelenchoides parietinus and Aphelenchus avenae. Phytopath. 26: 698-701.

Cobb, N. A. 1893. Plant diseases and their remedies: Diseases of the sugarcane. Agr. Gaz. N.S.W. 4: 777-833.

_____, 1893 a. Nematodes, mostly Australian and Fijian. Macleay Mem. Vol., Linn. Soc. N.S.Wales, Sydney. 252-308.

_____, 1913. Notes on Mononchus and Tylenchulus. J. wash. Acad. Sci. 3 (10): 287-288.

_____, 1913 a. New nematode genera found inhabiting fresh-water and non-brackish soils. Ibid. 3 (16): 432-444.

_____, 1914. North American free-living fresh-water nematodes. Contr. Sci. Nemat. II. Trans. Amer. Mic. Soc. 33: 35-99.

Cobb, N. A. 1914. Citrus root nematode. J. Agric. Res. Wash. 2 (3): 217-230.

_____, 1919. A new nema, Tylenchus musicola, n. sp., said to cause a serious affection of the Bluggoe banana in Grenada, British West Indies. West Indian Bull. 17: 179-182.

_____, 1920. A newly discovered parasitic nematode (Tylenchus mahogani n. sp.) associated with a disease of the mahogany tree. J. Parasitol. 6: 188-191.

_____, 1923. An amendation of Hoplolaimus Daday, 1905 nec auctores. J. Acad. Sci. 13 (10): 211-214.

_____, 1927. A new nema Aphelenchus retusus, with a proposed division of Aphelenchus into three subgenera. J. Parasitol. 14: 56.

_____, 1933. New nemic genera and species, with taxonomic notes. Ibid. 20: 81-94.

Colbran, R. C. 1956. Studies of plant and soil nematodes. I. Two new species from Queensland. Queensland J. Agr. Sci. 12: 123-126.

Daday, E. von. 1905. Untersuchungen über die Süsswasser-Mikrofauna Paraguays. Zool. Stuttg., 18 (44): 362-374.

Das, M. V. 1960. Studies on the nematode parasites of plants in Hyderabad (Andhra Pradesh, India). Zeit. f. Parasiten. 19: 553-605.

Fielding M. J. 1956. Tylenchorhynchus martini, a new nematode species found in the sugarcane and rice fields of Louisiana and Texas. Proc. Helm. Soc. Wash. 23: 47-48.

Filipjev, I. N. 1934. The classification of the free-living nematodes and their relation to the parasitic nematodes. Smith. Misc. Coll. 89 (6): 1-63.

Filipjev, I. N. 1936. On the classification of the Tylenchinae. Proc. Helm. Soc. Wash. 3: 80-83.

_____, and J. H. Schuurmans-Stekhoven, jr. 1941. A manual of Agricultural Helminthology. E. J. Brill, Leiden. 878 pp.

Fischer, M. 1894. Über eine Clematis-Krankheit. Ber. Physiol. Lab. Versuch. landw. Inst. Univ. Halle. 11: 1-11.

Franklin, M. T. 1955. A redescription of Aphelenchoides parietinus (Bastian, 1865) Steiner, 1932. J. Helm. 24: 65-76.

Fuchs, G. 1937. Neue parasitische und halbparasitische Nematoden bei Borkenkäfern und einige andere Nematoden. I. Teil. Zool. Jb. 70 (5/6): 291-380.

Godfrey, G. H. 1929. A destructive root disease of pineapples and other plants due to Tylenchus brachyurus n. sp. Phytopath. 19: 611-629.

Golden, A. M. 1956. Taxonomy of the spiral nematodes (Rotylenchus and Helicotylenchus) and the developmental stages and the host-parasite relationships of R. buxophilus n. sp., attacking boxwood. Bull. Md. Agric. Exp. Sta. A-85; 1-28.

Göldi, E. A. 1887. Relatorio sobre a molestia do cafeeiro na provincia do Rio de Janeiro. Apparently an advance separate of: Arch. Mus. Nacional Rio de Janeiro. 8: 7-121, 1892.

Goffart, H. 1953. Beobachtungen an Pflanzenschädlichen Nematoden I. Nachrichtenblatt des Deutschen Pflanzenshut. 5 (10): 150-153.

Goodey, J. B. 1951. The 'hemizonid' a hitherto unrecorded structure in members of the Tylenchoidea. J. Helm. 25: 33-36.

_____, 1952. Tylenchorhynchus tessellatus n. sp. (Nematoda: Tylenchida). Ibid. 26: 87-90.

Goodey, J. B. 1957. Hoplolaimus proporicus n. sp. (Hoplolaiminae: Tylenchida). Nematologica 2 (2): 108-113.

_____, 1958. Paraphelenchus myceliophthorus n. sp. (Nematoda: Aphelenchidae). Nematologica 3 (1): 1-5.

_____, 1958 a. Ditylenchus myceliophagus n. sp. (Nematoda: Tylenchidae). Ibidem 3 (2): 91-96.

Goodey, T. 1926. Hexatylus viviparus gen. et sp. nov., a nematode found in a diseased potato tuber. J. Helm. 4 (1): 27-30.

_____, 1927. On the nematode genus Aphelenchus. Ibid. 5: 203-20

_____, 1932. The genus Anguillulina Gerv., & v. Ben., 1859, vel Tylenchus Bastian, 1865. Ibidem 10: 75-180.

_____, 1933. Plant Parasitic Nematodes and the Diseases they Cause. Methuen & Co. London. 306 pp.

_____, 1934. Anguillulina cecidoplastes n. sp., a nematode causing galls on the grass, Andropogon pertusus Willd. J. Helm. 12: 225-236.

_____, 1936. On Anguillulina oryzae (v. Breda de Haan, 1902) Goodey, 1932, a nematode parasité of the roots of rice, Oryza sativa L. Ibidem 14: 107-112.

_____, 1940. On Anguillulina multicincta (Cobb) and other species of Anguillulina associated with the roots of plants. Ibid. 18: 21-38.

_____, 1951. Soil and Freshwater Nematodes. John Wiley & Sons. New York. 390 pp.

_____, 1953. On two new species of nematodes associated with leaf-blotch in Evodia roxburghiana an Indian evergreen tree. Thapar Comm. Vol., 1953. 95-102, 2 pls.

Graham, T. W. 1951. Nematode root rot of tobacco and other plants. Bull. S. C. Agr. Exp. Sta. 390: 25 pp.

Haan, J. van Breda de, 1902. Een Aaltjes-Ziekte der Rijst, 'omo Mentek' of 'omo Bambang'. Meded. Pl Tuin. Batavia, LIII.

Hirschmann, H. 1952. Die Nematoden der Wassergrenze mittlfraenkische Gewaesser. Zool. Jb. (Syst) 81: 313-407.

_____, 1955. Radopholus gracilis (de Man, 1880) n. comb. (Synonym —Tylenchorhynchus gracilis (de Man, 1880) Filipjev, 1936). Proc. Helm. Soc. Wash. 22: 57-63.

_____, 1955 a. Tylenchorhynchus gracilis (de Man, 1880) Filipjev, 1936. Radopholus gracilis (de Man, 1880) n. c. und seine Synonyme. Zool. Anz. 154: 288-301.

Hoffmänner, B. and R. Menzel. 1914. Neue Arten freilebender Nematoden aus der Schweiz. Ibid. 44: 80-91.

Hopper, B. E., and E. J. Cairns. 1959. Taxonomic keys to plant, soil and aquatic nematodes. Alabama Polytechnic Inst. Auburn, Alabama. 176 pp.

Hooper, D. J. 1958. Aphelenchoides dactylocercus n. sp. and A. sacchari n. sp. (Nematoda: Aphelenchoidea). Nematologica 3: 229-235.

Imamura, S. 1931. Nematodes in the paddy field, with notes on their population before and after irrigation. Jour. College of Agric., Imperial Univ. Tokyo. 11: 193-240.

Jacob, J. J. s'. 1959. Hoplotylus femina n. g., n. sp. (Pratylenchinae: Tylenchida) associated with ornamental trees. Nematologica 4: 317-321.

Kirjanova, E. S. 1941. Nematody zernovickh kur'tur. Bull. Inst. Zool. Appl. Leningrad 12: 235-266.

_____, 1948. Ten new species of nematodes from the family Ogmidae Southern, 1914. Publ. Acad. Sergei Alex. Zernov, Acad. Sci. USSR.

Kirjanova, E. C. 1951. Nematody pochvy khlopkovogo polya i tseliny v Golodnoi Stepi (Uzbekistan). Trav. Inst. Zool. Acad. Sci. URSS. 9: 625-657.

_____, 1955. Paranguina agropyri Kirjanova, Gen. et sp. n. (Nematodes). Ibidem 18: 42-52.

Kofoid, C. A., and W. A. White, 1919. A new nematode infection of man. J. Amer. Med. Assoc. 72: 567-569.

Krall, 1959. New and little known Tylenchids (Nematoda, Tylenchida), with a description of gynandromorphism in the genus Aphelenchoides (Russian text). Eesti NSV Teaduste Akad. Toimetised. VIII. Koide, Biol. Seer. Nr 3: 190-198.

Kreis, H. A. 1929. Freilebende terrestrische Nematoden aus der Umgebung von Peking (China). Zool. Anz. 84: 283-294.

Linford, M. B., and J. M. Oliveira. 1940. Rotylenchulus reniformis nov. gen., n. sp., a nematode parasite of roots. Proc. Helm. Soc. Wash. 7: 35-42.

_____, and F. Yap. 1940. Some host plants of the reniform nematode in Hawaii. Ibidem 7: 42-44.

Litvinova, N. F. 1946. Four new species of Tylenchorhynchus (Nematoda) from Kazakhstan. Proc. Zool. Soc. London. 116: 120-128.

Loof, P. A. A. 1956. Trophurus, a new tylenchid genus (Nematoda). Ver sl. en. Meded. Plantenz. k. Dienst 129. Jaerbock 1955: 191-195.

_____, 1958. Some remarks on the status of the sub-family Dolichodorinae, with description of Macrotrophurus arbusticola n. g., n. sp. (Nematoda: Tylenchidae). Nematologica 3: 301-307.

Loof, P. A. A. 1959. Miscellaneous notes on the genus Tylenchorhynchus (Tylenchinae: Nematoda). Nematologica 4: 294-306.

Loos, C. A. 1948. Notes on free-living and plant-parasitic nematodes of Ceylon. 3 —The genus Hemicycliophora de Man, 1921. Syn. Procriconema Micoletzky, 1925. Ceylon J. Sci. Sec B., Zoology, 23 (3): 119-124.

_____, 1949. Notes on free-living and plant-parasitic nematodes of Ceylon. 4. J. Zool. Soc. India. 1 (1): 17-22.

_____, 1949. Notes on free-living and plant-parasitic nematodes of Ceylon. 5. Ibidem 1: 23-25.

Lordello, L. G. E. 1955. Xiphinema krugi n. sp. (Nematoda, Dorylaimoidae) from Brazil with a key to the species of Xiphinema. Proc. Helm. Soc. Wash. 22: 16-21.

_____, and R. Cesnik. 1958. Alguns nematódeos do tomateiro. Rev. Brasil. Biol. 18 (2): 159-165.

_____, A. P. L. Zamith, and O. J. Book. 1954. Novo nematódeo parasito da batatinha. Bargantia 13: 141-149.

Luc, M. 1957. Radopholus lavabri n. sp. (Nematoda: Tylenchidae) parasite du riz au Cameroun Français. Nematologica 2: 144-148.

_____, 1957 a. Tylenchulus mangenoti n. sp. (Nematoda - Tylenchida) Ibidem 2: 329-334.

_____, 1958. Trois nouvelles espèces Africaines du genre Hemicycliophora de Man, 1921 (Nematoda, Criconematidae). Ibid. 3: 15-23.

_____, 1958 a. Les nématodes et le Flétrissement des cotonniers dan le Sud-ouest de Madagascar. Coton et Fibres Tropicales XIII, Fasc. 2. 1-18.

_____, 1959. Nouveaux Criconematidae de la Zone Intertropicale (Nematoda: Tylenchida). Nematologica 4: 16-22.

Man, J. G. de. 1876. Onderzoekingen over vrij in de aarde levende Nematoden. Tijdsch. Nederl. dierk. Vereen. 2: 78-196, pls. 3-13.

_____, 1880. Die einheimischen, frei in der reinen Erde und im Süssen Wasser lebenden Nematoden. Ibid. 5: 1-104.

_____, 1921. Nouvelles recherches sur les nématodes libres terricoles de la Hollande. Capita Zool. 1: 1-62, pls. 1-14.

Martin, G. C. 1955. Plant and soil nematodes of the Federation of Rhodesia and Nyasaland. Rhodesia Agric. J. 52: 346-361.

Menzel, R. 1917. Zur Kenntnis der freilebenden Nematodengattung Hoplolaimus v. Daday. Rev. Suisse de Zool. 25: 153-162.

Meyl, A. H. 1953. Beiträge zur Kenntnis der Nematodenfauna vulkanisch erhitzter Biotope I. Die terrikolen Nematoden im Bereich von Fumarolen auf der Insel Ischia. Z. Morph. Ökol. Tiere. 42: 67-116.

_____, 1954. Die bischer in Italien gefundenen frei lebenden Erd- und Süsswasser-Nematoden. Arch. Zool. Italiano 39: 161-265.

Micoletzky, H. 1917. Freilebende Süsswasser-Nematoden der Bukowina. Zool. Jahrb. 40: 441-586.

_____, 1922. Die freilebenden Erd-nematoden. Arch. f. Naturgesch., 1921. 87: 1-650.

_____, 1923. Frei lebende Nematoden der Wolga mit besonderer Berücksichtingung der Umgebung von Saratow (Svobandnozhivushchie nematody reki Volgi, Rabot. Volzhsk. Biol. Stantsii). &7: 3-29.

_____, 1925. Die freilebenden Süsswasser- und Moornematoden Dänemarks. Mem. Acad. Roy. Sci. Lettres Danemark (8). 10: 57-310.

Paetzold, D. 1958. Beiträge zur Nematodenfauna mittldeutscher Salzstellen im Raum von Halle. Wiss. Z. Univ. Halle. Math.-Nat. 8 (1): 17-48.

Paramonov, A. A. 1953. Revision of superfamily Aphelenchoidea Fuchs, 1937 (Nematoda, Tylenchata). K. I. Skrjabin Anniv. Vol. 1953: 488-496 (in Russian).

Peacock, F. C. 1956. The reniform nematode in the Gold Coast. Nematologica 1 (4): 307-310.

Raski, D. J. 1952. On the morphology of Criconemoides Taylor, 1936, with descriptions of six new species (Nematoda: Criconematidae). Proc. Helm. Soc. Wash. 19: 85-99.

_____, 1958. Nomenclatorial notes on the genus Criconemoides (Nematoda: Criconematidae) with a key to the species. Ibidem 25: 139-142.

Sauer, M. R. 1958. Hoplolaimus gracilidens, Radopholus inaequalis, and Radopholus neosimilis, three new tylenchs native to Victoria, Australia. Nematologica 3: 97-107.

Schuurmans Stekhoven J. H. 1951. Nématodes saprozoaires et libres du Congo Belge. Mém. Inst. Royal Sc. Nat. Belgique, 39: 1-79.

_____, and R. J. H. Teunissen, 1938. Exploration du Parc National Albert, Mission G. F. de Witte. Nématodes libres terrestres. Inst. des Parcs Nat. du Congo Belge. Bruxelles. 22: 229 pp.

Sher, S. A., and M. W. Allen. 1953. Revision of the genus Pratylenchus (Nematoda: Tylenchidae). Univ. Calif. Publ. Zool. 57 (6): 441-470.

Seinhorst, J. W. 1959. Two new species of Pratylenchus. Nematologica 4: 83-86.

Siddiqi, M. R., and M. A. Basir. 1959. On some plant-parasitic nematodes occurring in South India, with the description of two new species of the genus Tylenchorhynchus Cobb, 1913. Proc. 46th Indian Sci. Cong. Part IV, p. 35.

Skarbilovich, T. S. 1947. Revision of the systematics of the nematode family Anguillulidae Baylis and Daubney, 1926. Akad. Nauk. USSR. Compt. Rendus 57 (3): 307-308.

_____, 1959. On the structure of systematics of nematodes order Tylenchida Thorne, 1949. Acta Parasit. Polonica 7: 117-132.

Steiner, G. 1914. Freilebende Nematoden aus der Schweiz. Arch. Hydrobiol. Bd. 9: 259-276.

_____, 1924. On some plant parasitic nemas and related forms. J. Agr. Res. 28: 1059-1066.

_____, 1931. On the status of the nemic genera Aphelenchus Bastian, Pathoaphelenchus Cobb, Paraphelenchus Micoletzky, Parasitaphelenchus Fuchs, Isonchus Cobb and Seinura Fuchs. J. Wash. Acad. Sci. 21 (18): 468-475.

_____, 1934. Observations on nematodes parasitic in tubers of the cinnamon-vine (Dioscorea batatas). Proc. Helm. Soc. Wash. 1: 15-17.

_____, 1937. Opuscula Miscellanea Nematologica V. (1) Tylenchorhynchus claytoni n. sp., an apparently rare nemic parasite of tobacco plant. Ibid. 4: 33-39.

_____, 1941. Nematodes parasitic on and associated with roots of marigold (Tagetes hybrid). Proc. Biol. Soc. Wash. 54: 31-34.

_____, 1943. New nematodes associated with a disease of the papaya in Chile. Bol. Dept. San. veg. Santiago, Chile 3 (2): 95-110.

_____, 1945. Helicotylenchus, a new genus of plant-parasitic nematodes and its relationship to Rotylenchus Filipjev. Proc. Helm. Soc. Wash. 12: 34-38.

Steiner, G. 1949. Plant nematodes the grower should know. Proc. Soil Sci. Soc. Florida. 4 B. 72-117. (year 1942).

Sveshnikova, M. M. 1940. On a study of the fauna of nematodes on citrus plants. Ref. index on problems of plant quarantine. 2. VIZ USSR. H: 12-15.

Tarjan, A. C. 1956. Known and suspected plant-parasitic nematodes of Rhode Island II. Xiphinema americanum with notes on Tylencholaimus brevicaudatus n. comb. Proc. Helm. Soc. Wash. 23: 88-92.

_____, 1957. An emended description of the marine nematode genus Halenchus Cobb, 1933. Quart. J. Acad. Sci. 20: 121-125.

_____, 1958. A new genus, Pseudhalenchus (Tylenchinae: Nematoda), with description of two new species. Proc. Helm. Soc. Wash. 25: 20-25.

Taylor, A. L. 1936. The genera and species of the Criconematinae, a sub-family of the Anguillulinidae (Nematoda). Trans. Amer. Micr. Soc. 55 (4): 391-421.

_____, and W. Q. Loegering. 1953. Nematodes associated with root-lesions in abacá. Turrialba 3: 8-13.

Taylor, D. P., and W. R. Jenkins 1957. Variations within the nematode genus Pratylenchus, with the descriptions of P. hexincisus n. sp. and P. subpenetrans n. sp. Nematologica 2 (2): 159-174.

Thomas, K. M. 1948. Short notes on some diseases and pests of coffee. Monthly Bull. Indian Coffee Board. 12 (6): 5-6.

Thorne, G. 1934. Some plant-parasitic nemas, with description of three new species. J. Agr. Res. 49: 755-763.

_____, 1941. Some nematodes of the family Tylenchidae which do not possess a valvular median oesophageal bulb. The Great

Basin Naturalist, Utah. 2 (2): 37-85.

Thorne, G. 1939. A monograph of the nematodes of the superfamily Dorylaimoidea. Capita Zoologica. 8: 1-261.

_____, 1945. Ditylenchus destructor n. sp., the potato rot nematode, and Ditylenchus dipsaci (Kühn, 1857) Filipjev, 1936, the teasel nematode (Nematoda: Tylenchidae). Proc. Helm. Soc. Wash. 12: 27-33.

_____, 1949. On the classification of the Tylenchida, new order (Nematoda, Phasmidia). Ibid. 16: 37-73.

_____, 1955. Fifteen new species of the genus Hemicycliophora with an emended description of H. typica de Man (Tylenchida: Criconematidae). Ibid. 22: 1-16.

_____, and M. W. Allen. 1950. Paratylenchus hamatus n. sp. and Xiphinema index n. sp., two nematodes associated with fig roots, with a note on Paratylenchus anceps Cobb. Ibid. 17: 27-35.

Treub, M. 1885. Onderzoekingen over Sereh-Ziek Suikerriet gedaan in s'Lands Plantentuin te Buitenzorg. Meded uit s'lands Plant. Batavia. 1-39.

Tulaganov, A. 1941. Description of new species of nematodes of the genus Hoplolaimus. Reports from the Uzbeck State University, New Ser. No. 16, Biol. no. 11, Tashkent, S.S.R.

Vecht, J. van der, and B. Bergman. 1952. Studies on the nematode Radopholus oryzae (van Breda de Haan) Thorne and its influence on the growth of the rice plant. Gen. Agr. Res. Sta. Bogor. Indonesia. 1-82.

Whitehead, A. G. 1958. Rotylenchoides brevis n. g., n. sp. (Rotylenchoidinae n. sub-fam.: Tylenchida). Nematologica 3: 327-331.

Whitehead, A. G. 1959. Nothanguina cecidoplastes n. comb. syn. Anguina cecidoplastes (Goodey, 1934) Filipjev, 1936 (Nothotylenchinae: Tylenchida). Nematologica 4: 70-75.

_____, 1959. Hoplolaimus angustalatus n. sp. (Hoplolaiminae: Tylenchida). Ibidem 4: 99-105.

_____, 1959. Hoplolaimus aberrans n. sp. (Hoplolaiminae: Tylenchida). Ibidem 4: 268-271.

_____, 1959. Trichotylenchus falciformis n. g., n. sp., (Belonolaiminae n. sub-fam: Tylenchida Thorne, 1949) an associate of grass roots (Hyparrhenia sp.) in Southern Tanganyika. Ibidem 4: 279-285.

Winslow, R. D. 1958. The taxonomic position of Anguillulina obtusa Goodey, 1932 and 1940. Ibidem 3: 136-139.

Zimmermann, A. 1898. Die Nematoden der Koffiewortels. Meded. Plantentuin. Batavia. 27: 16-41.

_____, 1904. Eenige pathologische en physiologische waarnemingen aver Koffie. Mededel. 'sLands Plantentuin (Buitenzorg). 67: 89-92.

REFERENCES

Part II

Adams, R. E. 1955. Evidence of injury to deciduous fruit trees by the ectoparasitic nematode (Xiphinema sp.) and a promising control measure. Phytopath. 45 (9): 477-479.

Allen, M. W. and H. J. Jensen. 1951. Pratylenchus vulnus, new species (Nematoda: Pratylenchinae), a parasite of trees and vines in California. Proc. Helm. Soc. Wash. 18 (1): 47-50

Anderson, E. J. and I. Yanagihara. 1955. A method for estimating numbers of motile nematodes in large numbers of soil samples. Phytopath. 45: 238-239.

Ark, P. A. and H. E. Thomas. 1936. Anguillulina pratensis in relation to root injury of apple and other fruit trees. Phytopath. 26:(1128-1134.

Baines, R. C. 1950. Nematodes on citrus. Soil fumigation and resistant citrus varieties promising as controls. Calif. Agriculture. 4: 7.

_____. 1950 a. Citrus-root nematode investigations. Calif. Citrograph. 35: 344-345.

_____, and O. F. Clarke. 1952. Citrus-root nematode, effects on young lemon and orange trees studied in inoculation tests under controlled conditions. Calif. Agriculture 6: 9, 13.

_____, R. H. Small, T. A. DeWolfe, J. P. Martin and L. H. Stolzy. 1957. Control of the citrus nematode and Phytophthora spp. by Vapam. Pl. Dis. Reptr. 41 (5): 405-414.

_____, T. A. DeWolfe and R. H. Small. 1958. Control of the

citrus nematode, Phytophthora spp. and weeds by Mylone 85W when applied by different methods. Pl. Dis. Reptr. 42 (7): 876-880.

Baines R. C., S. D. Van Gundy, and S. A. Sher. 1959. Citrus and avocado nematodes. Calif. Agriculture 13 (9): 16-18.

Birchfield, W. 1956. New and suspected host plants of the burrowing nematodes Radopholus similis (Cobb) Thorne. Pl. Dis. Reptr. 40: 866-868.

_____. 1957. Observations on the longevity without food of the burrowing nematode. Phytopath. 47: 161-162.

_____, and Bistline, F. 1956. Cover crops in relation to the burrowing nematode, Radopholus similis. Pl. Dis. Reptr. 40: 398-399.

_____, 1957. The burrowing nema situation in Florida. Jour. Economic Entomology 50 (5): 562-564.

_____, and W. J. Martin. 1956. Pathogenicity on sugarcane and host plant studies of a species of Tylenchorhynchus. Phytopath. 46 (5): 277-280.

Bosher, J. E., and W. Newton. 1956. Hot water treatment of apple stock for the control of nematodes. Ibid. 46: 634-635.

Caveness, F. E., and H. J. Jensen. 1955. Modification of the centrifugal-flotation technique for the isolation and concentration of nematodes and their eggs from soil and plant tissues. Proc. Helm. Soc. Wash. 22: 87-89.

Chitwood, B. G. 1949. Ring nematodes (Criconematinae). A possible factor in decline and replanting problems of peach orchards. Ibid. 16: 6-7.

_____, W. Birchfield. 1956. Nematodes, their kinds and characteristics. Bull. State Plant Board of Florida Vol. II, No. 9. 49 pp.

Chitwood, B. G., and B. A. Oteifa. 1952. Nematodes parasitic on plants. Ann. Review of Microbiol. 1952. 6: 151-184.

Christie, J. R. 1952. Some new nematode species of critical importance to Florida growers. Soil Sci. Soc. Fla. 12: 30-39.

_____, and V. G. Perry, 1951. Removing nematodes from soil. Proc. Helm. Soc. Wash. 18: 106-108.

Cobb, N. A. 1913. Notes on Mononchus and Tylenchulus. J. Wash. Acad. Sci. 3 (10): 287-288.

_____. 1914. Citrus-root nematode. J. Agric. Res. 2 (3): 217-230.

_____. 1919. A new nema, Tylenchus musicola n. sp., said to cause a serious affection of the bluggoe banana in Grenada, British West Indies. West Indian Bull. 17: 179-182.

Crossman, L., and J. R. Christie. 1937. Lists of plants attacked by miscellaneous plant-infesting nematodes. Pl. Dis. Reptr. 21: 144-167.

Esser, R. P. 1957. An improved post Baermann funnel technique. Ibid. 41: 269-270.

Feder, W. A., and J. Feldmesser. 1954. The Büchner funnel as an aid in collecting and concentrating nematode populations. Ibid. 38: 805-806.

_____. 1955. Progress report on studies on the reproduction of the burrowing nematode, Radopholus similis (Cobb) Thorne, on citrus seedlings growing in petri dishes. Ibid. 39: 395-396.

Feldmesser, J., W. A. Feder, and J. A. Pinckard. 1956. The occurrence of Pratylenchus spp. in Florida soils. Phytopath. 46: 11, Abs.

Fielding, M. J. 1956. Tylenchorhynchus martini, a new nematode species found in the sugarcane and rice fields of Louisiana and Texas. Proc. Helm. Soc. Wash. 23: 47-48.

_____, and J. H. Hollis. 1956. Occurrence of plant parasitic nematodes in Louisiana soils. Pl. Dis. Reptr. 40: 403-405.

Gadd, C. H., and C. A. Loos. 1941. Observations on the life history of Anguillulina pratensis. Ann. Appl. Biol. 28: 39-51.

Godfrey, G. H. 1929. A destructive root disease of pineapples and other plants due to Tylenchus brachyurus n. sp. Phytopath. 19: 611-629.

Graham, T. W.,1951. Nematode root rot of tobacco and other plants. South Carol. Agri. Exp. Sta. Bull. 390. 25 pp.

_____, 1954. Recent developments with ectoparasitic nematode Pl. Dis. Reptr. 38: 80.

_____, 1955. Pathogenicity of Rotylenchus brachyurus on tobacco and of Criconemoides sp. on tobacco and peanuts. Phytopath. 45: 347, Abs.

Gundy, S. D. van. 1957. The first report of a species of Hemicycliophora attacking citrus roots. Pl. Dis. Reptr. 41: (12): 1016-1018.

_____, 1958. The life history of the citrus nematode, Tylenchulus semipenetrans Cobb. Nematologica 3: 283-294.

_____, 1958 a. The pathogenicity of Hemicycliophora arenaria on citrus. Phytopath. 48: 399, Abs.

_____,I. J. Thomason, and R. L. Rackhan, 1959. The reaction of three citrus spp. to three Meloidogyne spp. Pl. Dis. Reptr. 43: 970-971.

Hastings, R. J. 1939. The biology of the meadow nematode. Canadian

Jour. Res. Sec. D. 17: 39-44.

Hollis, J. P., and M. J. Fielding, 1956. Relatedness of ovary length and rate of reproduction in plant nematodes. Phytopath. 46: 15, Abs.

Jackson, L. W. R. 1948. Deterioration of short leaf pine roots caused by a parasitic nematode. Pl. Dis. Reptr. 32: 192.

Kirjanova, E. C. 1948. Ten new species of nematodes from the family Ogmidae Southern, 1914. Pamjati Akad. Serej. Alex. Zernova Akad. Nauk CCCP. 346-358 (in Russian).

Krusberg, L. R. 1959. Investigations on the life-cycle, reproduction, feeding habits and host-range of Tylenchorhynchus claytoni Steiner. Nematologica 4: 187-197.

_____, and J. N. Sasser. 1955. The lance nematode, Hoplolaimus coronatus, a parasite of cotton. Phytopath. 45: 349, Abs.

_____,1956. Host-parasite relationships of the lance nematode in cotton roots. Ibid. 46: 505-510.

Loof, P. A. A. 1959. Ueber das Vorkommen von Endotokia matricida bei Tylenchida. Nematologica 4: 238-240.

Lownsbery, B. F. 1956. Pratylenchus vulnus, primary cause of the root-lesion disease of walnuts. Phytopath. 46: 376-379.

Machmer, J. H. 1953. Criconemoides sp., a ring nematode associated with peanut "yellows". Pl. Dis. Reptr. 37: 156.

Mai, W. F., and K. G. Parker. 1956. Evidence that the nematode Pratylenchus penetrans causes losses in New York State Cherry orchards. Phytopath. 46: 19, Abs.

Marchionatto, J. B. 1947. La podredumbre de la raicella de los citrus provocada por el Tylenchulus semipenetrans. Inst. San. Veg., Min. Agri. Nacion. Buenos Aires. Ser. A, Anno.III,

no. 35, 6 pp.

Martin, W. J., and W. Birchfield. 1955. Notes on parasitic nematodes in Louisiana. Pl. Dis. Reptr. 39: 3-4.

Paetzold, D. 1958. Bemerkungen zur "Endotokia matricida" von Lordello 1951. Wiss. Z. Martin-Luther-Univ. Halle-Wittenberg 7: 81-83.

Perry, V. G. 1958. Parasitism of two species of dagger nematodes (Xiphinema americanum and X. chambersi) to strawberry. Phytopath. 48: 420-423.

Reynolds, H. W., and M. M. Evans. 1953. The stylet nematode, Tylenchorhynchus dubius, a root parasite of economic importance in the Southwest. Pl. Dis. Reprtr. 37: 540-544.

_____, and O'Bannon. 1958. The citrus nematode and its control in living citrus in Arizona. Ibid. 42: 1288-1292.

Schindler, A. F. 1954. Root galling associated with dagger nematode, Xiphinema diversicaudatum (Micoletzky, 1927) Thorne, 19: Phytopath. 44: 389, Abs.

_____, 1957. Parasitism and pathogenicity of Xiphinema diversicaudatum, an ectoparasitic nematode. Nematologica 2: 25-31.

_____, and A. J. Braun. 1957. Pathogenicity of an ectoparasitic nematode, Xiphinema diversicaudatum, on strawberrie: Ibid. 2: 91-93.

Sher, S. A. 1959. A disease of carnations caused by the nematode, Criconemoides xenoplax. Phytopath. 49: 761-763.

_____, M. W. Allen. 1953. Revision of the genus Pratylenchus (Nematoda: Tylenchidae). Univ. Calif. Publ. Zool. 57 (6): 441-470.

Sher, S. A., F. J. Foote, and S. B. Boswell. 1959. A root-lesion nematode disease of avocados. Pl. Dis. Reptr. 43: 797-800.

Srivastava, A. S., and K. P. Katiyar. 1956. Effects of diazinon, salicylic acid and benzoic acid on wheat nematodes. Proc. 43rd Meet. Indian Sci. Cong. Assoc. Abs. Part III. p. 286.

_____, and H. P. Saxena. 1956. Effects of diazinon on paddy nematodes. Ibid. p. 286.

Steiner, G. 1949. Plant nematodes the grower should know. Proc. Soil Sci. Soc. Fla. 4 B, 72-117.

Stöckli, A. 1943. Über Methoden zur quantitativen Bestimmung der im Boden freilebenden Nematoden. Ber. Schweiz. Bot. Gesell. 53 A: 160-174.

_____, 1950. Über die quantitative Bestimmung der Bodennematoden. Zeitsch. Pflanz., Düngung u. Bodenk. 51:1-22.

Suit, R. F., and E. P. DuCharme. 1953. Parasitic nematodes in relation to spreading decline of citrus. Calif. Citrograph. 38 (9); 307: 319-322.

_____, 1957. Spreading decline of citrus. State Plant Board of Fla. Bull. 11, Vol. II. 24 pp.

Tarjan, A. C. 1950. Investigations of meadow nematodes attacking boxwood, and the therapeutic value of sodium selenate as a control. Phytopath. 40: 1111-1124.

Taylor, A. L., and W. Q. Loegering. 1953. Nematodes associated with root-lesions in abacá. Turrialba 3: 8-13.

Thomas, E. E. 1913. A preliminary report of a nematode observed on citrus roots and its possible relation with the mottled appearance of citrus trees. Circ. 85, Calif. Agric. Exp. Sta. 1-14.

Thorne, G. 1948. Nematodes as a disturbing factor in greenhouse, plot and field experiments. Pl. Dis. Reptr. 32: 473-475.

_____, 1949. On the classification of the Tylenchida, new order (Nematoda, Phasmidia). Proc. Helm. Soc. Wash. 16: 37-73.

Viggars, R. M., and A. C. Tarjan. 1949. A new root disease of pin oak possibly caused by the nematode, Hoplolaimus coronatus Cobb. Pl. Dis. Reptr. 33: 132-133.

White, F. A. 1947. Notes on citrus nematodes. Calif. Citrograph. 32 (7): 312-313.

Zimmermann, A. 1898. Die Nematoden der Koffiewortels. Meded. Plantentuin. Batavia. 27: 16-41.